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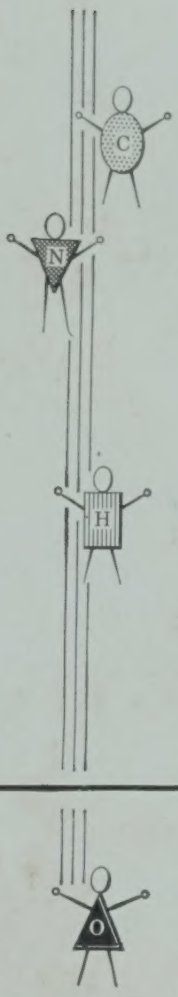
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Principles of Nutrition

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Dedicated

To the memory of H. K. Wilson

Preface

The purpose of this textbook is to provide basic information in utrition at the elementary level, particularly for college students, elating the role of nutrition to their own well-being and to that of ociety as a whole. A background in neither chemistry nor physiol-gy is presumed on the part of the reader. An attempt has been ade throughout the book, however, not to avoid the concepts drawn om chemistry and physiology basic to an understanding of nutrition, ut rather to explain them through features of the book developed for at purpose. The chapter, "Terms One Needs to Know for the tudy of Nutrition," is included to explain concepts and terminology ore fully than is feasible in the discussions or than could be accom-lished in a glossary. Illustrations and diagrammatic drawings, de-icting information that seems abstruse in the printed page, have been repared and are included in this chapter. In addition, we include a lossary of words, other than those given in the chapter on terms, at the beginning student is likely to be meeting for the first time. or the sake of clarity specialized technical terminology is avoided henever it seems possible to do so without limiting the "nutrition ocabulary" of the student.

In the forepart of the book, basic information on energy metabolism nd food nutrients is included, with particular reference to the needs f the college student. Applications of nutrition principles to the eeds of children, women during pregnancy and lactation, and older ersons, and to selected problems including obesity, undernutrition, nd the relation of diet to dental health follow in the later chapters.

It is expected that the sections devoted to applied nutrition will be of special interest to the nutritionist in the field.

Supplementary readings for the student are included at the close of most chapters. The references are chiefly for the purpose of documenting information and in some instances for suggesting further reading on the subject.

It was a pressing problem to present at the elementary level a reasonable summation and interpretation of the voluminous findings from the extensive and pertinent nutrition research of our times. Many questions currently remain unsettled, of course. To give the beginning student sufficient confidence in our present information and at the same time to equip him with the necessary readiness for changes that are certain to come was our continuous challenge as the manuscript developed. The statement that Dr. Lafayette B. Mendel made years ago applies to the situation at hand: "The science of nutrition is in the midst of a continual evaluation of facts and development of truth. For the present, therefore, we should 'first get the facts.'"

We are grateful to the scientists whose research findings are the fundamental core of this book. It is our earnest desire that our use of these data is logical and consistent with the conditions of the study.

We wish to express appreciation to the many persons who encouraged and aided us in the writing of the text and who gave generously of their time and thought: to Mrs. Mary Howell and Mrs. Mabel Fraser for their assistance in preparation of the manuscript; to Mrs. Helen Guthrie and Miss Gilma Olson for reading the entire text and offering constructive suggestions; to Mrs. Sarah McGrew for her assistance with illustrations involving biochemical reactions; to Dr. George Barron for his help in setting up some of the energy illustrations.

Authorities in their fields took time from their busy schedules to read critically and constructively portions of the book: the late Dr. A. K. Anderson, Dr. George P. Barron, Miss Alice Biester, Dr. Mary L. Dodds, Dr. Icie Macy Hoobler, Dr. Frances Johnston, Dr. Miriam E. Lowenberg, Mrs. Ethel Austin Martin, Dr. Olaf Mickelsen, Dr. Margaret Ohlson, Dr. Ruth Pike, Dr. James H. Shaw, Dr. Genevieve Stearns, Dr. T. S. Sutton, and Dr. Raymond W. Swift. Others who gave the benefit of their judgment were Dr. Ercel Eppright, Dr. Frances Godshall, Miss Ina Padgett, Mrs. Katherine Peterson, Dr. Inez Prudent, and Dr. Grace Steininger.

The students in our classes in elementary nutrition gave us many of the ideas that are incorporated in the book. Furthermore, they served as a testing ground for most of the features included.

We wish to mention the very special encouragement and assistance iven us by the late Dr. H. K. Wilson, Mr. John L. Fisher, and Mr. nd Mrs. F. Y. Fuqua.

Eva D. Wilson
Katherine H. Fisher
Mary E. Fuqua

uly, 1959

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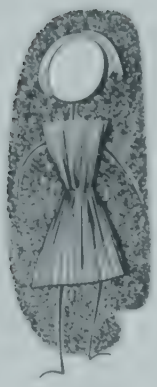
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CHAPTER 1





Nutrition and you

A college student registering for classes asked, "What is nutrition? Do you think I should study it?" These questions are fundamental and deserve a reply. The response to the student follows, constituting the introductory chapter to this textbook.

First of all, an answer to the question, "*What is nutrition?*" Nutrition is the science of nourishing the body. It is concerned with learning the kinds and amounts of materials to be supplied in the day's food to keep the cells of the body operating properly. Furthermore, nutrition includes the study of the composition of different foods to know how best to provide the needed materials in the diet. Very early after we begin the study of nutrition, we gain an appreciation of the veritable laboratory of the finest scientific caliber that we maintain within us. For that laboratory to function in building our body and keeping it in running order, the right food must be provided.

And why should nutrition be studied? The primary reason for knowing the essentials of an adequate diet, and how to provide it, is that *good nutrition* is essential to *good health.* For the body to operate properly it must be provided with the materials necessary for its normal functioning. There is no means for the body to glean its sustenance other than by the food that we choose to eat.

Good nutrition does not just happen. Nature has endowed us with the *desire to eat;* also we are capable of some discernment as to *how*



Fig. 1. Dennis the Menace, by Hank Ketcham. (Copyright 1958, The Hall Syndicate Inc.)

much we should eat. There is another aspect of eating for which man, even with his capabilities, has not a natural judgment, at least to our knowledge, and that is the selection of an adequate diet for himself. The attributes of an adequate diet must be learned; the information is provided us through studies and observations.

It is clearly evident from studies of food habits that people like what they eat. If they are accustomed to *black-eyed-peas*, they wish to continue to have them. If *rice* has been a major item in the diet, satisfaction is not achieved without it. This tendency to prefer the familiar strongly commands that nutrition education begins early.

Some of the benefits of good nutrition are readily recognized; others are not. The good posture, firm muscles, and abundant vitality of a well-nourished person result from the consumption of an adequate diet over a period of time. There are other benefits less apparent. If we feel no aches or pains, in fact are unaware of the busy activities inside us, that in itself is a positive sign that the body is functioning well and has been supplied the right nourishment. We cannot always judge the status of nutrition from the exterior. Whether or not our storehouses are adequately stocked with nutrients may not be apparent, unless a marked deficiency exists. Furthermore, the benefits of the added stores may not be realized immediately (as Dennis implies, Fig. 1), but will be of good use during times of stress.

Nutrition does make a difference. With children, poor nutrition is manifested in failure to grow normally and in other symptoms of lack of well-being. Adults too are affected by the kind of diets they eat. Among women factory workers those who showed a high incidence of absenteeism ate less adequate diets than those who were not absent in over a year's time. Although other factors may have been involved also, the dietary difference without a doubt played an important role (*5*).

The performance of an athlete can be impaired significantly by a faulty or an inadequate diet, even before clinical signs of a deficiency appear. One of the requirements for ability to perform well in an athletic event is a well-functioning body (7).

A good diet helps to assure more vitality in health. It is a bulwark against illness and an essential aid in recovery for persons who are ill.

Nutrition Is Basic in Some Professions

We have discussed numerous reasons for studying nutrition for the sake of personal health. In addition, a knowledge of nutrition is a part of the professional training of many. The elementary course is the basis for further study. Among those by whom nutrition is needed in their professional work are:

The dietitian or food service director, who plans adequate diets for hospital patients if she is a hospital dietitian, for school children if she is a school lunch supervisor, and for restaurant, cafeteria, and tea room patrons if she manages a public eating place.

The community nutritionist, who helps families to plan for the best use of their resources to provide a good diet; she may be with the agricultural extension service, a public health nursing association, or a social agency.

THE HOMEMAKER, who holds a major responsibility for the adequacy of the diets of her family.

THE PHYSICIAN, who uses diets not only as a specific treatment for certain diseases but also as a part of general therapy important to the recovery of all patients.

THE PHYSICAL EDUCATION TEACHER, who wishes to pass on to his students the essentials of an adequate diet to help keep their bodies fit for superior performance.

THE ELEMENTARY TEACHER, who is concerned with the development of the whole child, including his status of nutrition.

THE HOME ECONOMICS TEACHER, who as a part of her program teaches nutrition to high school and elementary school children.

The Beginning of the Study of Nutrition

Before beginning the study of present day nutrition we ask the question, "What is the origin of nutrition?"

The first record of man's effort to probe the mysteries of nourishment of the body was in ancient times. Ever since the search has continued (*1–4, 6*). It is with sincere respect that we read the prophetic statements of the early philosophers. In the first century B.C., Egyptians held the belief that excessive eating was the cause of many diseases. In the ancient world a Greek philosopher, Hippocrates (460–359 B.C.), pondered on the problems of medicine and of the body's reaction to food. Without advantage of experiment the brilliant philosopher propounded beliefs, some of which are sustained today. Among his aphorisms is the statement translated to read, "Growing bodies have the most innate heat; they require the most food, for otherwise their bodies are wasted. In old people the heat is feeble and they require little fuel, as it were, for it would be extinguished by much." His pronouncement that "Persons who are naturally very fat are apt to die earlier than those who are slender" is not unfamiliar in the literature of today (*2*).

After the Middle Ages, a period in history regarded as "intellectually barren," there arose in the Italian Renaissance a genius of many talents, Leonardo da Vinci (1452–1519). At the same time artist, anatomist, biologist, and aeronautical engineer, he made statements about nutrition that have a modern connotation.

Concerning the need for nourishment—

> . . . if you do not supply nourishment equal to the nourishment departed, life will fail in vigor; and if you take away this nourishment, life is utterly destroyed

the need for oxygen—

Where flame cannot live no animal can sustain its existence (2).

Born shortly after the death of Leonardo, Sanctorius (1561–1636), a professor at Padua, Italy, went to great trouble to investigate a question that troubled many of that era and which, to be sure, is under study still today. Sanctorius experimented; he spent much of his life weighing himself. He found that he lost weight during periods "when no additional food or drink was taken and no sensible evacuations from the body occurred." He termed this loss "insensible perspiration."

When Sanctorius was performing his experiments, there was no science of chemistry. In the years that followed, chemical discoveries were made that paved the way for nutrition discoveries also. In the seventeenth century the mysteries of "air" and of processes of respiration were under investigation. Most significant were the experiments of John Mayow (1643–1679). He placed a small animal and a burning candle in a closed jar. He observed that the candle burned a longer time without the animal in the jar, the animal lived a longer time in the jar without the burning candle. Mayow at the age of 25 years wrote a treatise on respiration. With perceiving vision he stated that "the particles of the air absorbed during respiration are designed to convert the black or venous blood into the red or arterial." This young scientist died when he was only 36 years of age, cutting short his brilliant career.

About a century elapsed before others took up the studies of respiration. In a period of about 15 years four men were born who made discoveries that laid the groundwork for the science of nutrition.

Joseph Black (1728–1799), a physician and professor at the University of Edinburgh, discovered what he termed "fixed air," later identified as carbon dioxide. He found that by breathing through a tube into lime water, it became cloudy; also when poured into a jar in which a candle had been burned, the lime water became cloudy. Black proposed that all kinds of animals expire "fixed air."

Priestley (1733–1804) and Scheele (1742–1786) independently discovered oxygen at about the same time. Priestley was a Unitarian clergyman in England, Scheele a Swedish apothecary and chemist.

Priestley thought that animals exhausted the air, and that flames did so also. He wondered how the air once "exhausted" could be revitalized. He found the answer by burning a candle in a jar until it went out, and then placing a living plant (a sprig of mint) in the jar. Ten days later he placed another candle in the enclosed space and found that it burned perfectly well; the living plant had revitalized

the air. Priestley produced oxygen by heating red oxide of mercury in a closed vessel with the heat of the sun focused by means of a burning glass.

Scheele performed an experiment in which he placed two large bees with a little honey in a small box fitted in the top of a glass cylinder. He immersed the cylinder in limewater after filling it with "fire-air" (his term for oxygen) that he had obtained by heating mercuric oxide. After eight days the bees were both dead and the limewater had risen in the container. The "fire-air" had been used up by the bees and the carbon dioxide given off was absorbed in the limewater.

It was Antoine Laurent Lavoisier (1743–1794) who brought together the findings of his predecessors to explain the phenomenon of respiration. He studied the respiration of animals, and also of his associate, Seguin. Lavoisier supported the theory that ordinary air is a mixture of oxygen and nitrogen gases, that during respiration the nitrogen returns unchanged, but the oxygen is diminished. He found that when Seguin had eaten food, he absorbed more oxygen than without it and that exercise increased the absorption of oxygen.

The achievements that lead to the modern era of nutrition often did not bring honor to the men with the brilliant minds. Priestley, unhappy with the reception of his work on the continent, came to America in 1794, making his home in Northumberland, Pennsylvania, where he spent the remainder of his life. Lavoisier was executed at the age of fifty-one for alleged criminal acts during the French Revolution. One of Lavosier's friends said of him, "It took but a second to cut off his head; a hundred years will not suffice to produce one like it."

It was during the nineteenth century that great strides were made in identifying the materials needed in the diet for life and well-being. Only a very few of the noted scientists of the time are mentioned here. Magendie (1783–1855), a French scientist who observed that when he fed dogs sugar alone, or butter, or olive oil, or gum arabic together with distilled water the animals died. He concluded that the protein element was necessary. Not only was Magendie distinguished for his own research, but for being the teacher of Claude Bernard, (1813–1878), who discovered glycogen and also proclaimed that pancreatic juice performs some function that is necessary for the absorption of fats. In Germany, there were Liebig (1803–1873) who taught that fats and carbohydrates were fuel foods, and termed the nutrient that formed body tissues during growth "plastic food," and Voit (1831–1908) who believed that "the requirement of protein is dependent on



Fig. 2. Lavoisier and his wife. (Courtesy, The Rockefeller Institute.)

the organized mass of the tissues; the requirement for fat and carbohydrate is dependent on the amount of mechanical work accomplished" (2).

That brings us to the twentieth century and our own times. Never in the whole previous history of nutrition have the strides of this century been paralleled. Studies of this era have encompassed the discovery and the identification of certain nutrients (the vitamins, amino acids, and certain minerals), the nutrient needs of the body in health and in disease, the specific and inter-related functions that these nutrients play, sources of these nutrients and their use to enrich food to a higher nutritive value—all for the benefit of mankind. The "one world" concept was ushered in in the the twentieth century and with it concern in nutrition not for an adequate diet for the people of our nation alone, but for food enough for the world's people. Some of the scientists and certain of their contributions will be cited in the chapters to follow.

The Chapters to Follow

As we set forth to acquaint ourselves with the characteristics of an adequate diet and the means of achieving it, we will find that it is necessary to understand certain processes and terminologies referred to frequently throughout the book in order to gain the full significance of the discussion. The chapter that follows immediately is devoted to an explanation of such terms. It is placed early in the book so that it can be read at the start and then referred to later as the terms arise in subsequent chapters.

The remaining chapters are devoted to the essentials of an adequate diet, the energy, the protein, mineral, and vitamin needs, with methods for planning a food intake to supply these nutrients. The benefits of good nutrition; the disadvantages of poor nutrition; the nutritional needs of special groups, children, women during pregnancy and lactation, and older persons are all discussed in succeeding chapters. The appendix includes a glossary of terms used in the book that may be new to the reader, and tables to supplement the reading, which are too extensive to be placed in the body of the text.

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CHAPTER 2

Terms one needs to know for the study of nutrition

There are many terms customarily used in a beginning course in nutrition for college students that may be unfamiliar to them, particularly if they have not studied chemistry or physiology. Inasmuch as this book is intended to be understandable to students without an extensive science background, some terms are defined in this chapter with a fuller explanation than is feasible in the discussions where they occur. Other terms that may be new are explained briefly in the chapters when they occur.

ELEMENT. An element is a substance which cannot be subdivided by ordinary physical or chemical means. Oxygen, iron, and copper are examples of elements.

COMPOUND. A compound is a substance made up of two or more elements which can be subdivided by ordinary physical or chemical means. Water, iron rust, and fats are examples of compounds.

INORGANIC COMPOUND. An inorganic compound is one that does not contain carbon in its structure. Compounds such as hydrochloric acid, table salt, and others belong to this classification.

ORGANIC COMPOUND. An organic compound is one that contains carbon atoms in its structure. Carbohydrates, fats, proteins, hormones, enzymes, and vitamins are all organic compounds.

ACID. An acid is a chemical substance that usually has a sour taste and contains hydrogen atoms in its structure. There are two general types of acids: inorganic acids and organic acids. Hydrochloric, sulfuric, and phosphoric acids are examples of inorganic acids. In Chapter 5, the importance of hydrochloric acid in digestion will be pre-

ented. Organic acids differ from the inorganic in that they have arbon atoms as well as hydrogen atoms in their structure. Acetic cid, the acid found in vinegar, is an example of this type of acid. ome of the important organic acids in nutrition are the amino acids, arbonic acid, pyruvic acid, lactic acid, and others.

Base. A base or alkali, as it is sometimes called, is a chemical substance that will neutralize an acid to form a salt. Ordinary ammonia, which is used for household cleaning, is an example of an alkali. Alkalies are important in the normal functioning of the body. Because they neutralize the excess amounts of acid formed during body processes, the neutrality of the body is maintained within its optimal range.

The metric system of weights and measures. In nutrition, weights and measures are not expressed in terms of the United States system, as in everyday life, but rather in terms of metric units. Weight is measured in terms of kilograms or grams, not pounds or ounces; liquid measure is expressed in terms of liters or milliliters, not quarts, pints, or ounces; and length is measured in terms of meters or centimeters, not feet or inches. A table of the metric units used in nutrition as well as several of the United States equivalents are presented.

METRIC UNITS OF WEIGHT

1 kilogram (kg) = 1000 grams (gm)
1 gram (gm) = 1000 milligrams (mg)
1 milligram (mg) = 1000 micrograms (mcg)

METRIC UNITS OF LIQUID MEASURE

1 liter (l) = 1000 milliliters (ml)

METRIC UNITS OF LENGTH

1 meter (m) = 100 centimeters (cm)
1 centimeter (cm) = 10 millimeters (mm)

U.S. EQUIVALENT OF METRIC UNITS

1 lb = 0.454 kg or 454.5 gm
1 oz = 28.4 gm
1 pt = 0.473 l or 473.2 ml
1 in = 2.5 cm

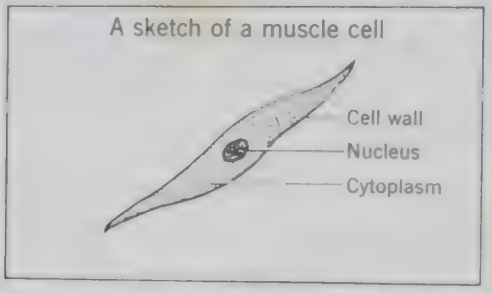
Hormone. Hormones are chemical substances produced by the ductless glands of the body. These chemical substances after production, pass directly into the blood stream and thence to the various cells and tissues where they act. The word "hormone," itself, is derived from the Greek and means "I excite." The general name of a gland that produces a hormone is an endocrine gland. The endocrine glands that are important to the study of nutrition are (1) the thyroid, (2) the parathyroid, (3) the adrenal, (4) certain cells of the pancreas (Islets of Langerhans), and (5) the pituitary. Some important hormones produced by these glands are (1) thyroxine, (2) para-

thyroid hormone, (3) cortisone and epinephrine (commonly called adrenalin), (4) insulin, and (5) the pituitary hormones.

MINERAL. A mineral is an inorganic substance which may or may not be essential for good health in animals and man. There are fourteen different mineral elements which have come to be known as essential because they are needed for good health by at least two species of animals. Calcium, phosphorus, iron, iodine, sodium, potassium, chlorine, sodium, magnesium, manganese, zinc, copper, cobalt, and molybdenum belong to the group of essential nutrients.

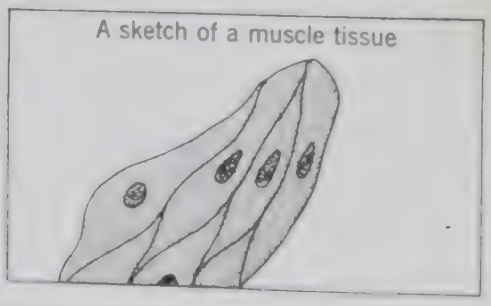
VITAMIN. Vitamin is the general name given to a group of organic substances that are necessary in very small amounts for the normal functioning of the body. The name itself means "an amine (which is a chemical substance) essential for life." At the present time, there are fifteen known vitamins. For a substance to be classified as a vitamin, it must be needed by at least two species of animals for good health. Vitamins are classified in two groups: the fat-soluble and the water-soluble. The fat-soluble ones include vitamins A, D, E, and K, while ascorbic acid, thiamine, riboflavin, niacin, vitamin B_6, pantothenic acid, biotin, folacin, vitamin B_{12}, choline, and inositol belong to the water-soluble group.

CELL. A cell is the smallest individual unit that makes up all living tissue. Although cells vary in size and shape, each one is encased in



a membrane called the cell wall and may or may not contain a nucleus. The inside of the cell contains a semi-liquid substance called the cytoplasm.

TISSUE. A tissue is defined as a group of similar cells working together to perform a particular function. There are many kinds of



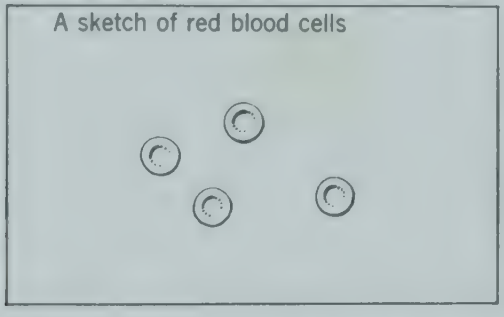
issue, such as muscle tissue, nerve tissue, bone tissue, and others, all of which are composed of many individual cells.

. Organ. An organ is described as a part of the body composed of group of tissues that perform several functions. For example, the tomach is classed as an organ. It is composed of several different inds of tissues. There are the tissues responsible for the secretion of he digestive juices as well as those responsible for the muscular move- nent of the stomach walls.

Blood. Blood is the fluid which circulates through the body bring- ng nourishment to and removing waste products from the cells. The lood travels throughout the body by way of the arteries and veins, ut reaches the cells by way of smaller passageways, the capillaries. Over one-half of the blood is composed of a clear, colorless fluid called he plasma, the remainder is made up of formed substances: the red ells, the white cells, and the platelets.

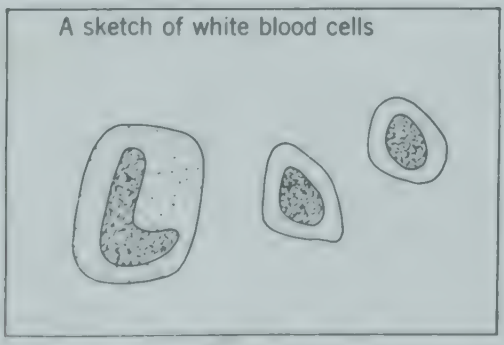
Plasma. The plasma is the main vehicle in the blood taking the utrients and hormones to the tissues and carrying waste products rom the tissues to the kidneys and lungs.

Red blood cell. The red blood cell, which is small and disc- haped, contains hemoglobin, a substance that carries oxygen to the



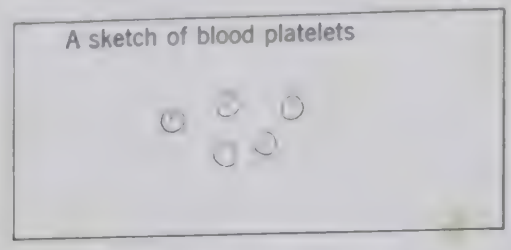
ells. These red cells, or erythrocytes, are manufactured in the mar- ow of the bone. A normal healthy college man will have about 5 illion red cells per cubic millimeter of blood.

White blood cell. The white cells or leucocytes are large cells hat contain a well-defined nucleus and granules in the cytoplasm.



These cells, which are also formed in the bone marrow, serve as the body's defense against invading bacteria. Under normal conditions of health, between 5000 and 9000 cells will be found in one cubic millimeter of human blood.

Blood platelets. The platelets or thrombocytes are disc-shaped cells found in the blood, and they aid in the coagulation of the blood.



Capillaries. The capillaries are very small blood vessels that extend into the tissues and cells. The capillaries begin at the end of the smallest arteries and end at the beginning of the smallest veins.

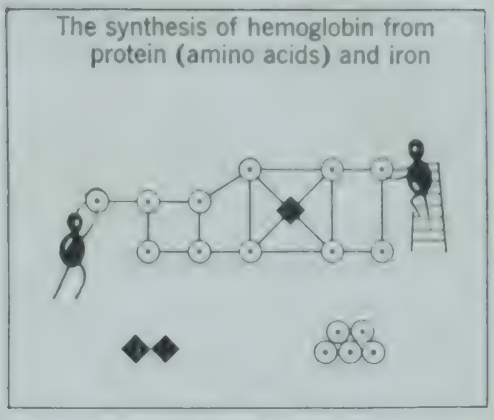
Lymph. Lymph is the liquid material of the lymphatic system, which drains the tissue spaces of the body. The tiny lymph vessels begin in the tissues where there is an actual exchange between the cells and the blood, and join with other lymph vessels to form larger ones. Finally, after reaching the chest region, the lymph passes into the blood stream by way of a lymph duct, which is located there.

Calorie. A calorie is the standard unit used to measure energy. The calorie used in nutrition is called the kilogram or large calorie and is written with a capital letter (Calorie or Cal.). This unit is one thousand times greater than the small calorie (calorie or cal.) used in chemistry or physics. Although the word "Calorie" is often used to describe the potential energy in food, it is not a nutrient but rather a unit of measure of heat.

Calorimetry. Calorimetry is the measurement of the amount of heat given off or absorbed. The energy value of a particular food or the daily energy needs of a person are both determined by calorimetry and expressed in terms of Calories. If the measurement is made from the actual heat produced, this is referred to as direct calorimetry. On the other hand, if the amount of oxygen consumed and or the carbon dioxide produced is used as a basis to indirectly measure heat production, this is called indirect calorimetry.

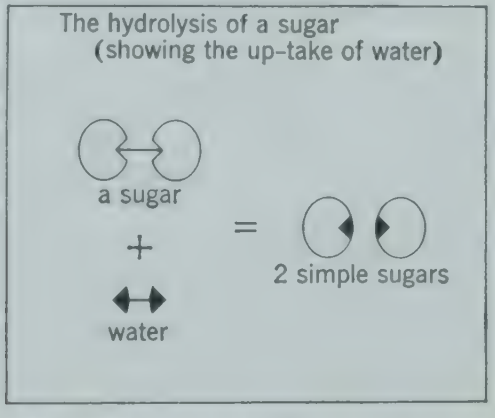
Calorimeter. A calorimeter is the instrument or apparatus used to measure the calories of heat produced.

Synthesis. Synthesis is the process whereby a chemical or biological substance is built up from its individual parts. In the body the synthesis of different materials is going on all of the time. For ex-



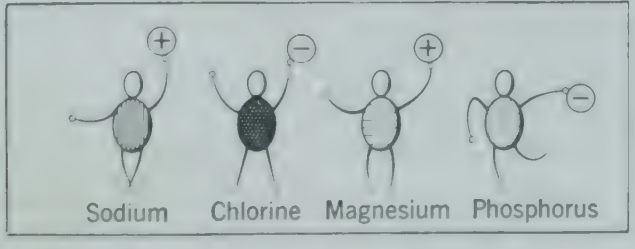
mple, hemoglobin, the material in the red blood cells that carries xygen to the tissues and cells, is constantly being synthesized from rotein and iron. The word synthesize, is the verb form of synthesis.

HYDROLYSIS. Hydrolysis is a process whereby a complex substance broken down into simpler units. The process itself involves the p-take of a molecule of water. The subdivision that carbohydrates,



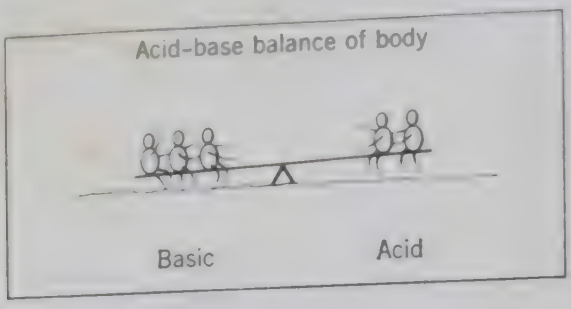
ats, and proteins undergo during digestion is due to hydrolysis. The ord, hydrolyze, is the verb form of hydrolysis, and the products ormed from the process of hydrolysis are sometimes referred to as ydrolytic products.

ION. An ion is an atom or group of atoms that carries a charge of ositive or negative electricity. Atoms of sodium, potassium, and



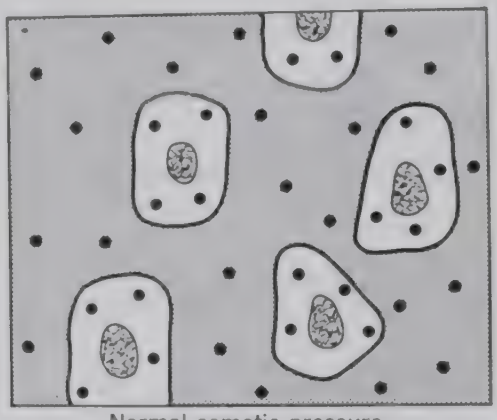
agnesium are examples of positive ions, whereas chlorine and phos-horus represent examples of negative ions.

ACID-BASE BALANCE. The acid-base balance is a hypothetical relationship of acid to alkali (base) in the body. The amount of base is in slight excess over the acid, as reflected in the blood, which is just on the alkaline side of neutrality. In the normal body processes



of supplying energy, building and repairing body tissue, and body regulation, acids are produced that must be removed or counteracted to keep the blood at an ideal alkalinity. Proteins, as well as certain minerals, aid in the maintenance of the acid-base balance.

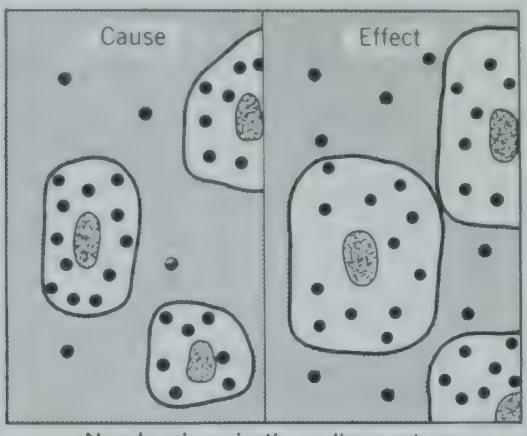
OSMOTIC PRESSURE. The osmotic pressure within the cell and of the tissue fluid surrounding it is a regulating factor of the normal water content of all living cells. The semipermeable membrane of the cell wall permits the passage of water and certain ions to and from the fluids that surround the cells. The concentration of ions in a fluid


Normal osmotic pressure

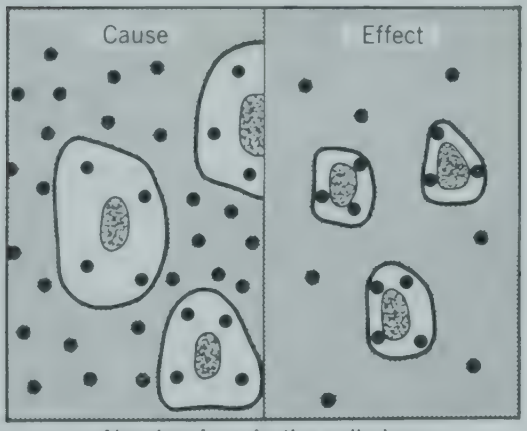
determines its osmotic pressure. When the concentration of ions in the cell and outer fluids are equal, there is no change in cell volume. This represents the normal osmotic pressure. If the ion concentration within the cell is greater than that in the surrounding fluid, the imbalance created results in water passing into the cell and causing it to swell. In contrast to this, if the concentration of ions in the cell is less than that of the extracellular fluid, the cell shrinks, as a result of the passage of water from the cell into the outer fluid. The process

y which fluids pass from a solution of greater concentration of ions
o one of lesser is osmosis.

Sodium, potassium, and magnesium play an important role in the smotic pressure balance. Sodium is the chief ion in the body fluid; otassium and magnesium are the chief ions within the cells themselves.

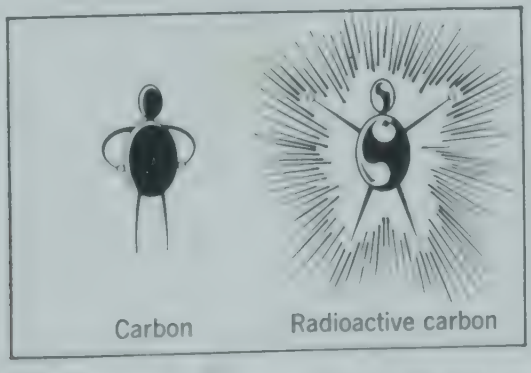


Number ions in the cells greater than in outside fluids



Number ions in the cells less than in outside fluids

RADIOACTIVE ELEMENTS. A radioactive element is a substance that gives off particles of matter that can penetrate a solid material and can



be measured by suitable instruments. Certain radioactive elements, such as carbon, hydrogen, iron, and calcium, have been used to study biological reactions because these elements can be used to "tag" the compound under study. Normally, radioactive elements do not occur in the body. Consequently, it is possible to distinguish these elements from those naturally present in the body. Although radioactive elements are used most often in this way, the radioactive form of iodine is now being used in the treatment of hyperthyroidism, a disorder in which the thyroid gland oversecretes the hormone, thyroxin.

Recommended dietary allowances. The Recommended Dietary Allowances are suggested daily intakes of Calories and nutrients for persons of the United States. The Food and Nutrition Board of the National Research Council developed the allowances on the basis of published research and the combined judgment of a large number of nutrition authorities. The term, Recommended Allowances, was chosen by the Board "to avoid any implication of finality of standards or of minimal or optimal requirements." The allowances are not requirements but represent nutrient intakes sufficiently generous to cover individual variations in a substantial majority of the population. Numerous terms are used in referring to the Recommended Dietary Allowances—NRC (National Research Council) Recommended Allowances, Food and Nutrition Board Recommended Allowances, Recommended Allowances, and Recommended Daily Allowances.

National Research Council. The National Research Council was formed in 1916 by the National Academy of Sciences, an organization of leading scientists, in cooperation with the major scientific and technical societies of the country. The purpose of the Council is to enable scientists and engineers to associate their efforts with those of the Academy in service to science and to the government. Foods and nutrition is only one of the many areas represented in the National Research Council. The Food and Nutrition Board established in 1940 is advisory in the area of food and nutrition. The members appointed to the Board are chosen from the leaders in the field.

Institute of Home Economics, U.S. Department of Agriculture. The Institute of Home Economics develops, through research, new knowledge about nutrition, consumer use of food, fibers, and other products, and efficient household management. The research is carried on in three Divisions: Human Nutrition, Clothing and Housing, and Household Economics. The office and laboratories of the Institute are located in Washington, D.C., and nearby Beltsville, Maryland. In this book, findings from research in the Division of Human Nutrition and Household Economics are cited frequently.

Food and Agriculture Organization of the United Nations. he Food and Agriculture Organization of the United Nations AO) is concerned with the problems of nutrition of the people of e world. Through FAO, the pooled efforts of nations are directed the problems of increasing production and providing food for ople who do not have enough. The world situation of food and riculture is reviewed at regular intervals and reported to the mem- r nations for their use. The headquarters office of FAO is in ome, Italy.

CHAPTER 3

The functions of food

Eating is an essential part of the daily lives of everyone. Colleges and universities, recognizing the importance of food for the student body, provide food service facilities on the campus. Even though the chief function of the food is to supply materials to meet physiological needs, it serves other functions also. Food plays an integral role in social life, whether on the college or university campus (Fig. 3) in the homes of the land, or in the affairs of the convening diplomats of the world. Still another function of food is that of the psychological or emotional influence. Familiar foods are favorite foods, imparting a sense of well-being and satisfaction unrelated to food value but reminiscent of past experiences.

The Physiological Function of Food

The physiological function of food may be divided into three general categories: the need for food materials to supply energy, the need for food materials to build and maintain the cells and tissues, and the need for food materials to regulate body processes. These needs are satisfied by substances called *nutrients* which are found in the food man eats. The nutrients themselves have been subdivided into six general classes: carbohydrates, fats, proteins, minerals, vitamins, and water. The next thirteen chapters are devoted to the discussion of the part that these food factors play in the maintenance of good health.

e need for food nutrients to supply energy

nasmuch as the primary function of food is to supply the body th energy-producing materials, the energy demand must be satisfied ore the body uses food for building and maintenance, or regulation. e nutrients in foods which supply energy are called the *energy rients;* they include the carbohydrates, fats, and proteins. Under rmal conditions of health and good eating habits, the body will de- e most of the energy needed from the carbohydrates and fats in od. Even though protein is generally classified as a tissue-building repairing nutrient, it can be used as a source of energy. Protein is ed for energy when there is insufficient carbohydrate and fat in the od intake to meet the energy demands. Protein foods are more pensive and less plentiful than either carbohydrate or fat foods. sing protein for energy has been compared to burning costly cherry ood when a cheaper wood, such as pine, would give the same nount of heat. Further discussion will follow in Chapter 5.

e need for food nutrients to build and maintain body tissue

Nutrients used in the building and maintenance of the body are roteins, minerals, and water. The most abundant body building utrient is water, followed by protein, with minerals occurring in the ast amount (see Chapter 9). Each cell and tissue contain some of ch of the body building nutrients. The specific location and struc- ral function will be discussed in the chapters concerning the re- pective nutrients.

ne need for food nutrients to regulate body processes

All of the nutrients with the exception of carbohydrates and fats lay a role in the regulation of the body processes. The proteins, the inerals, the vitamins, and water each perform regulatory functions ssential to the normal functioning of the body, such as the movement f fluids, the control of the acid-base balance, the coagulation of lood, and the maintenance of normal body temperature. The role of ne specific food nutrients in these physiological functions and others ill be discussed in the chapter devoted to that nutrient.

The Social Function of Food

Food has always served an important function in the social ex- nanges of people. In the ancient world, guests could be invited nly when the store of food was sufficient to provide for present and uture wants (*1*). The social occasions centering around food in our



Fig. 3. Food as part of college social functions. (Courtesy Laverne Henderson The Pennsylvania State University.)

country are many—the sugaring off parties of Vermont and New Hampshire at maple sugar time, the "at homes" at Christmas and New Year's in the South, the food festivals of the Middle West, and the outdoor hospitality of the Far West (*2*).

Inasmuch as food is an integral part of the social aspects of college or university living, this function is important to college men and women. Food is served at many college social events; teas, breakfasts, banquets, athletic award dinners, dances, and even after club meetings. At all of these affairs, the food is indirectly serving as an instrument to develop social rapport among all the students. For example, the purpose of refreshments after a club meeting may be indirectly to attract more students to the meeting but the main function is to create an atmosphere where social relationships may be fostered. When a college man or coed is asked to plan a menu for a social function, the important emphasis may not be, will the food provide all of the important nutrients needed for good nutrition, but rather, will the food please and create an atmosphere to make the social event a success. However, the food will satisfy in part the body's need for nourishment, which is its chief function.

The Psychological Function of Food

In addition to nourishing the body and filling a need in social life, food satisfies certain emotional needs. Even though a meal may be

equate nutritionally, the food may not leave the consumer with a se of genuine satisfaction. People who travel in a new land with familiar food customs often find it a problem to adjust to the anged dietary. Traditional habits result in certain foods pleasing e person and proving distasteful to another. The warmth and isfaction imparted when familiar and favorite foods are served nges on previous happy experiences.

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CHAPTER 4

The energy nutrients

As has already been discussed in Chapter 3, the first and most important function of food for the body is to supply energy. The food nutrients which are sources of potential energy for the animal organism to meet this need are the carbohydrates, fats, and proteins. The energy nutrients are manufactured in the tissues of plants, the "energy factories" of nature, from simple inorganic substances such as air and water. However, man and animals must obtain their energy supplies through the intake of either plant or animal foods.

The carbohydrates found in foods are the chief source of energy for the body. Even though fats contain more than twice as much energy per unit weight as do carbohydrates, the intake of carbohydrate is ordinarily greater than fat in the average diet. Nevertheless, we do not underestimate the importance of fats as energy contributors to the body. Although protein's main function in the body is to build and repair tissue, it is able to contribute energy for body processes. If the carbohydrate and fat content of the diet is below the desirable level, protein is used for energy at the expense of tissue building and repair because the first physiological demand of the body that must be satisfied is the energy need. Proteins, however, are not recommended as a source of body energy because protein foods are expensive and less plentiful than are the carbohydrate and fat foods. The discussion of the energy contribution of proteins is presented in Chapter 5.

The Carbohydrates

All carbohydrates contain carbon, hydrogen, and oxygen. In a mple carbohydrate unit, there are six carbon atoms grouped together a chain with atoms of hydrogen and oxygen attached to the ain in the same ratio as found in water, two to one. A simple ssification of some carbohydrates important in nutrition, based on e number of single carbohydrate units found in each chemical struc- re, is presented in Fig. 4. Compounds with one carbohydrate unit e called *monosaccharides* (Fig. 5), those with two units are desig- ted as *disaccharides*, and *polysaccharides* is the term used to describe mpounds with more than two carbohydrate units in their chemical ucture. The three illustrated monosaccharides are the carbohy- ate units contained in the structures of di- and polysaccharides. he mono- and disaccharides are soluble in water, crystalline in struc- re, and have a sweet taste; they are called sugars and all have the aracteristic name ending, *-ose*. In contrast, most polysaccharides e insoluble in water; they do not form crystals, do not taste sweet, d have neither a group name nor a characteristic ending.

e monosaccharides

The three monosaccharides that are important in the study of trition are glucose, fructose, and galactose. Glucose, sometimes

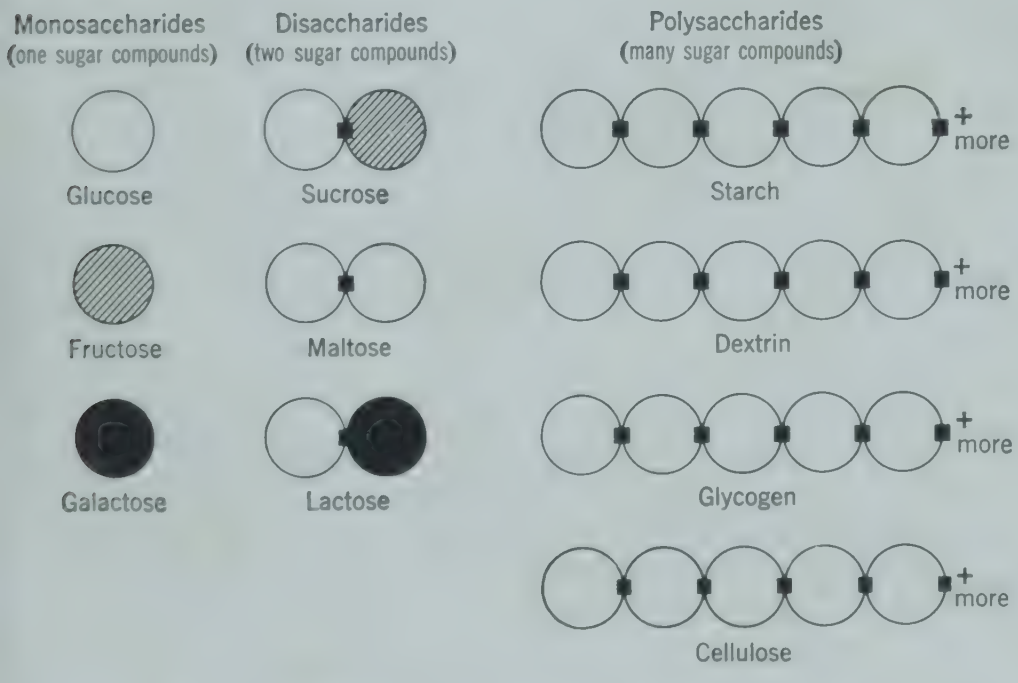


Fig. 4. A simple classification of the carbohydrates.

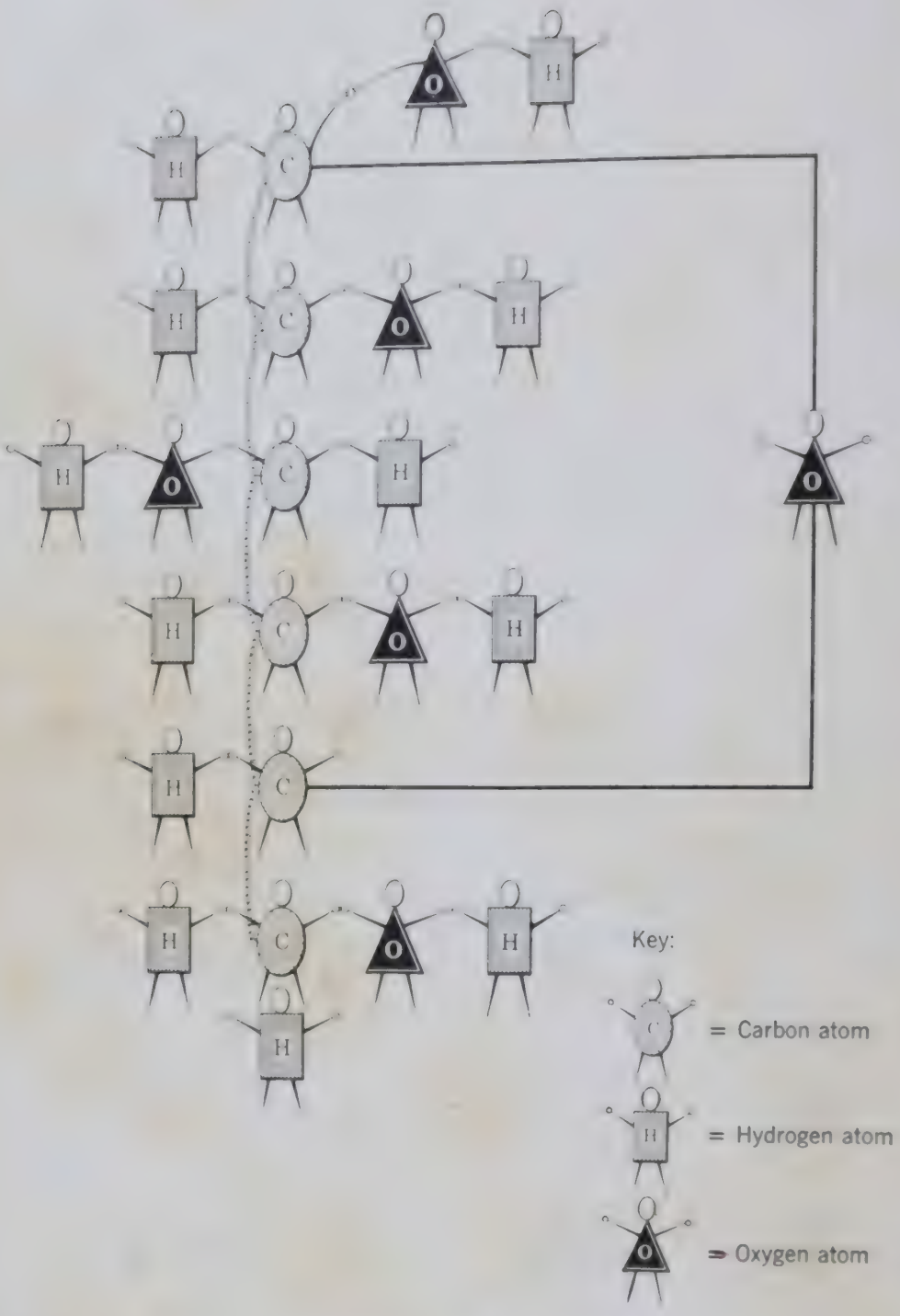


Fig. 5. A diagrammatic representation of the chemical formula of a monosaccharide, glucose.

ed dextrose or grape sugar, is widely distributed in nature. It is carbohydrate found in the blood stream of animals; it is produced the animal body during the digestion of starches, sucrose, maltose, lactose. In the plant kingdom, glucose is found in fruits, vegeles, and sap. Fructose, which has the sweetest taste of all the gars, is often called fruit sugar. It is found in the nectar of flowers, fruits, and in vegetables, and is produced during the hydrolysis of crose in digestion. Galactose, however, does not occur free in ture like glucose and fructose, but is produced in the body during digestion of the disaccharide, lactose.

e disaccharides

Sucrose, maltose, and lactose are the three disaccharides that are ntained in the foods of the diet. Sucrose, the white and brown gar that we use each day, is produced from sugar cane and sugar ets. Although cane and beet sugar differ slightly in texture and lor, they have the same caloric value and can be used interchangely. This almost pure carbohydrate is consumed in large quantities the American people. The consumption of cane sugar in the nited States increased markedly after the First World War and has mained at a high intake level throughout the years except for the me of rationing in the Second World War period. A 1958 report om the U.S. Department of Agriculture on food consumption shows e average per capita consumption of sucrose to have been 97.1 lb for e year 1957, approximately 1.9 lb each week (*5*). Sucrose occurs some fruits and vegetables. Glucose and fructose are formed when crose is hydrolyzed during digestion. Maltose or malt sugar ocurs in sprouting grain, malted cereals, malted milk, and corn syrup; owever, the most important source of maltose for the body is as an termediate product of starch digestion. When hydrolyzed, maltose elds two molecules of glucose. Lactose or milk sugar, which yields ucose and galactose on hydrolysis, is found only in the milk of ammals.

ne polysaccharides

The polysaccharides are complex carbohydrates that may contain many as 2000 simple carbohydrate units arranged in long chains ther as a straight or branched structure. Starch, dextrin, glycogen, nd cellulose are four polysaccharides that are important in the study f nutrition.

Starch is the most abundant carbohydrate in the diet probably beuse it is so widely distributed in the plant kingdom where it occurs

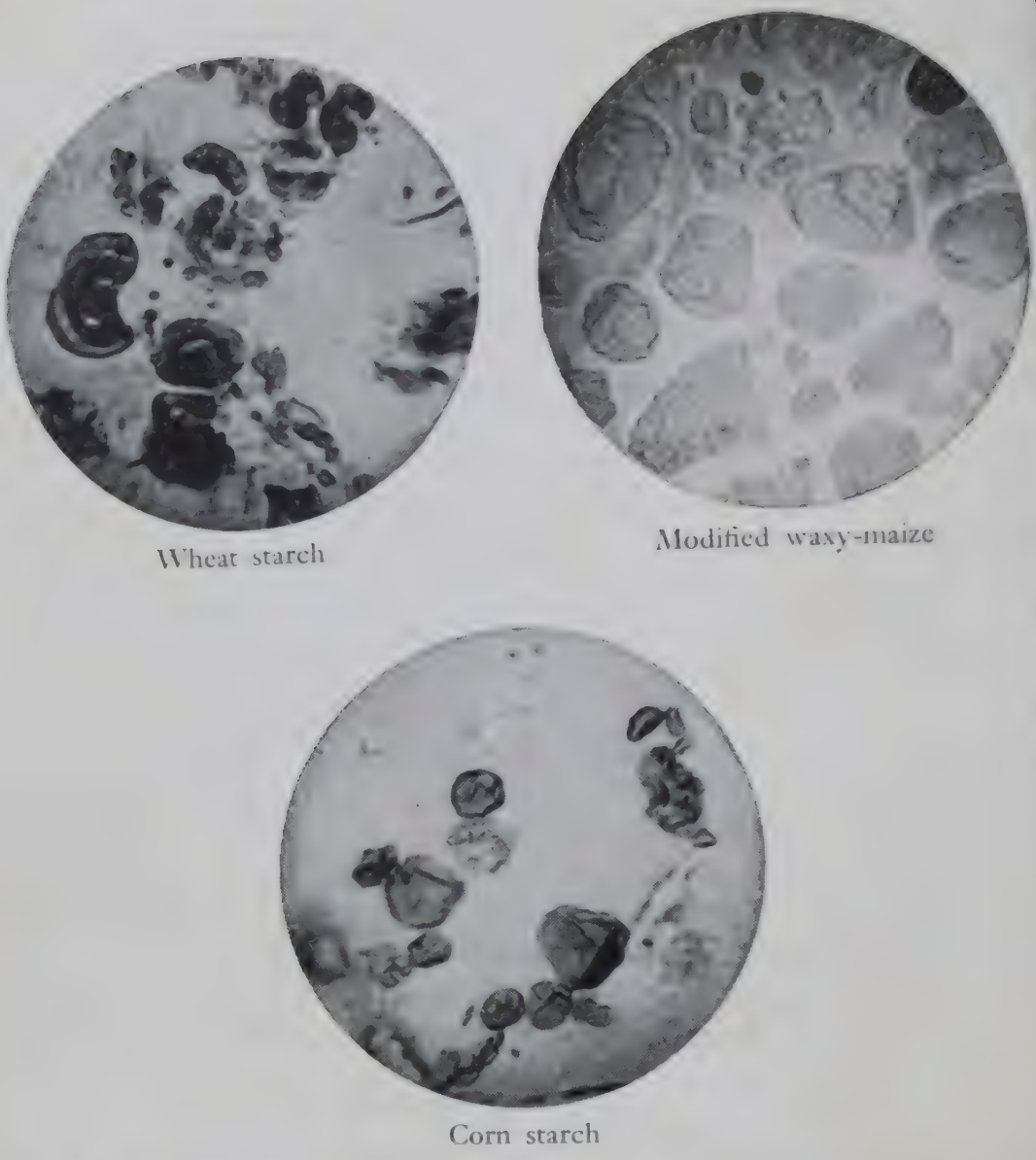


Fig. 6. Microscopic appearance of gelatinized starches. (Courtesy of Elizabeth Hester, The Pennsylvania State University.)

in roots, seeds, and tubers. In the tissue of a plant, starch is found in the form of granules. These granules are typical of the plants in which they are found and occur in different sizes and shapes and show different markings (Fig. 6). Wheat starch granules are oval-shaped; the granules of cornstarch are small, rounded, and angular. The starches do not dissolve in cold water but as the temperature of the water increases, the granules begin to swell and the mixture becomes viscous. This change is called gelatinization. Moreover, cooking makes starch-containing foods more palatable and more easily digested

the body. Glucose is the end-product of all starch hydrolyzed in e body.

The second group of polysaccharides, known as the dextrins, occur metabolic products in animals and plants and are particularly abunnt in germinating seeds. Actually, the dextrins are not too impornt as a source of carbohydrate because they are produced as intween products in the hydrolysis of starch to maltose and finally ucose, both in the preparation of foods and digestion of starch.

Glycogen is often referred to as *animal starch* because it is the storge carbohydrate of animals. Since the body does not have the apacity to store glycogen as it does fat, only about 350 gm or $\frac{3}{4}$ lb f it are found in the body as reserves. Approximately two-thirds of he body's glycogen is stored in the muscle and the rest is found in the ver. This carbohydrate is found in the liver of all animals and in mall aquatic animals called mussels.

The polysaccharide, cellulose, occurs only in plants where it has een described as the constituent of the structural cell wall since it nakes up the skeletal parts of all plants. This carbohydrate is not mportant to most mammals as a direct source of food because man nd animals, except for the ruminants, do not possess enzymes that an hydrolyze cellulose to glucose. The ruminant animals, such as he cow and sheep, have bacteria in their rumens (stomachs) that actiate the breakdown of cellulose to carbohydrate products that can be sed by the animal. Thus when an individual ingests products from hese animals, he is indirectly using cellulose as a source of food. In ddition to this, cellulose is important in the diet as a source of roughge to give bulk to the contents of the intestinal tract.

Function of carbohydrate

The chief function of carbohydrate is to supply energy for body rocesses. Carbohydrate foods add flavor to the diet, and the cereals nd bread furnish the body with some protein.

Recommended Allowances for carbohydrate

As yet, recommended daily dietary allowances for carbohydrate in he human diet have not been formulated. However, it has been estimated that between 50 and 60 per cent of the total Calories may come rom carbohydrate sources in a well-balanced diet.

Food sources of carbohydrates

The sugars, cereal grains, legumes, and dried fruits are the richest ources of carbohydrate found in the foods of the diet (Fig. 7).

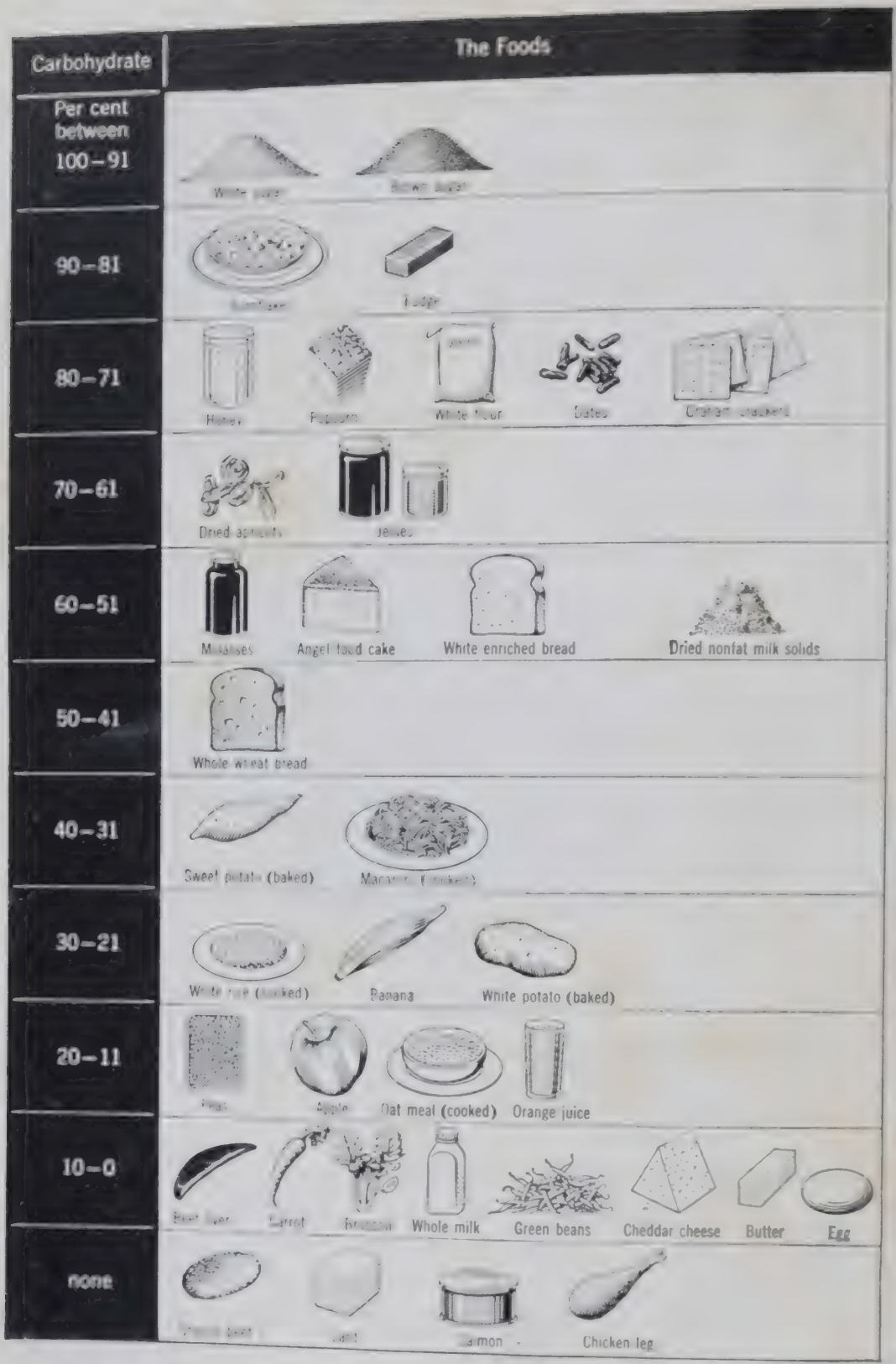


Fig. 7. The percentage of carbohydrate in some typical foods. (Adapted from values in *Composition of Foods*—Raw, Processed, Prepared. U.S. Department of Agriculture, Agriculture Handbook 8, 1950.)

White sugar is almost pure carbohydrate (99.5 per cent) while the real grains, legumes, and dried fruits vary in their content of the utrient. Some of the processed foods that contain appreciable quanties of carbohydrate are noodles, dried nonfat milk solids, pretzels, ms, jellies, pastries, breads, cakes, and candies. Although most fresh uits and vegetables are considered to be carbohydrate poor, bananas, ates, white potatoes, and sweet potatoes are good carriers of the utrient. Eggs, fish, poultry, cheese, fresh milk, and meats (with the xception of liver) however, contain little carbohydrate, and the nimal and vegetable fats none.

The Fats

Fats are composed of carbon, hydrogen, and oxygen, the same hemical elements found in carbohydrates. The ratio of hydrogen to xygen in the fat molecule, however, is much greater than that in a arbohydrate. For example, a fat found in beef which is called ristearin (Fig. 8) has 110 atoms of hydrogen to 6 atoms of oxygen as ompared to the 2 to 1 ratio of the same elements in the carbohydrate, lucose (Fig. 4). When a fat is burned in the body, additional oxyen must be supplied by the cells to combine with all the carbon and ydrogen atoms, thus more heat is produced. For this reason, a gram f pure fat gives the body 9 Cal. of energy whereas a gram of pure arbohydrate yields only 4 Cal.

There are essentially four parts to every fat molecule. The core f the molecule is made up of a three-chain carbon compound called *lycerol* (Fig. 8), which is related to the family of alcohols. Then ttached to each of the three carbon units of the glycerol molecule are hained compounds called *fatty acids.* The simplest fatty acid is cetic acid which is familiar, for it is the substance that gives vinegar ts sour taste. The fatty acids have interesting names, and a few of he common ones found in fats are myristic, palmitic, stearic, oleic, utyric, linoleic, and caproic acids. The three fatty acids found in he fat, tristearin (Fig. 8), are all the same—stearic acid. In addition, ats may have three different fatty acids or a combination of two alike nd one different.

The form of a fat, whether it is liquid or solid, depends on the kind f fatty acids found in its structure. Certain fatty acids, such as steric acid (Fig. 8), contain as many hydrogen atoms as the carbon toms can hold, and this is called a *saturated fatty acid.* In contrast, here are others that are mising a few hydrogen atoms in their carbon hains; they are referred to as *unsaturated fatty acids.* A fat that is

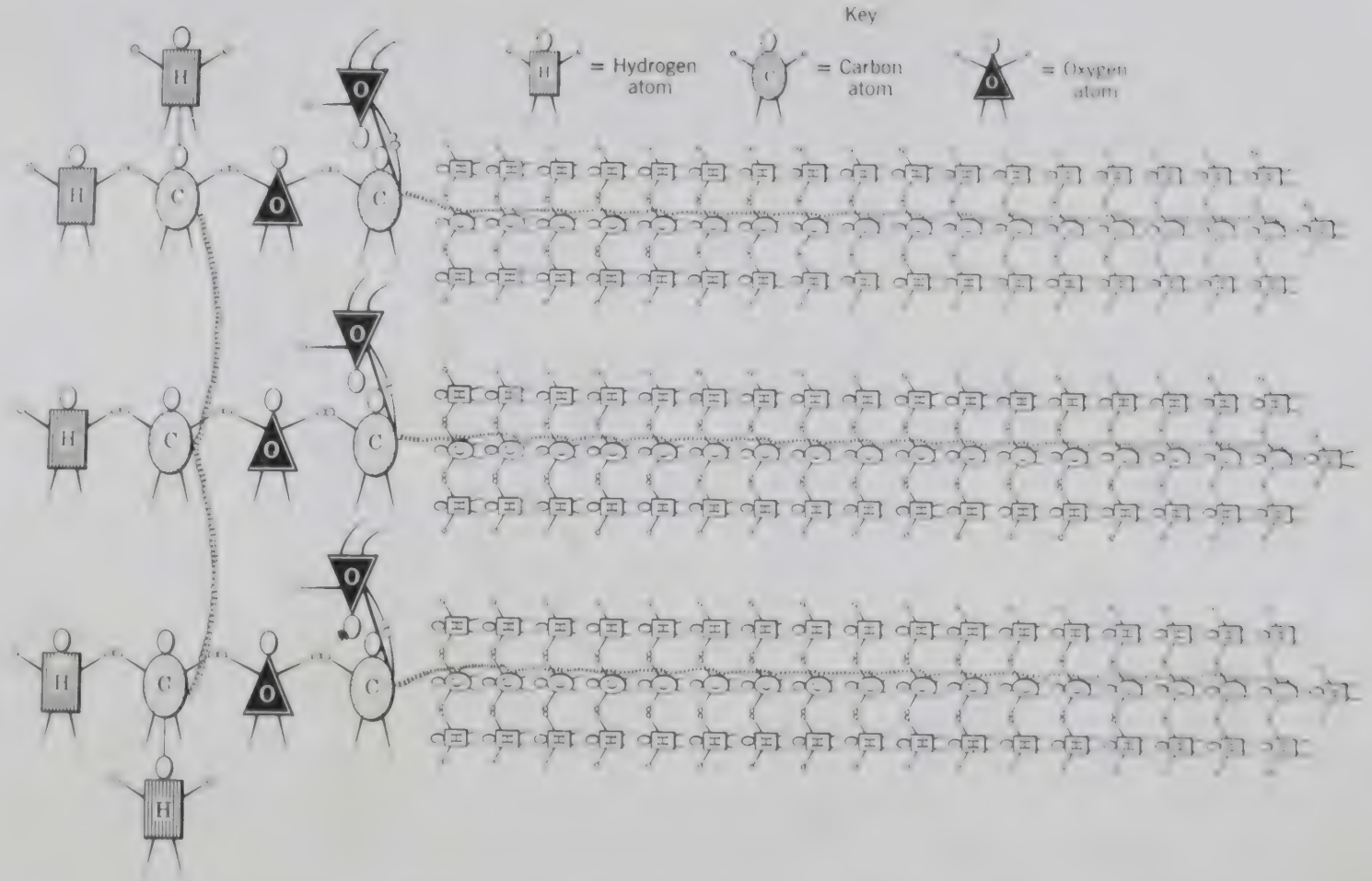


Fig. 8. A diagrammatic representation of the chemical formula of tristearin (a fat found in beef.)

uid at room temperature is called an oil and contains more of the saturated fatty acids, whereas a fat that is solid at room temperature ntains more of the saturated fatty acids in its structure.

A manufacturing process called the *hydrogenation of fats* has been veloped to convert many of the less appealing and less useful vege-ble oils to solid fats. Because hydrogen can be added to the un-turated fatty acids of these oils, changing them to saturated acids d thus increasing the melting point, the hydrogenation of cotton-ed, peanut, soybean, coconut, and palm oils to vegetable shortenings, s developed into a business involving millions of dollars. In addi-n to the vegetable shortenings, the production of margarine also pends upon the use of hydrogenated mixtures of fats.

nction of fats

Fats play an important role in human nutrition, because they are urces of energy, of the fat-soluble vitamins, and of the essential tty acids in the diet. In addition, fat foods in meals help to delay e onset of hunger. Fat deposits in the body serve as insulation and rovide protective cushions for the organs.

Source of energy. Fats are the most concentrated form of energy foods, yielding more than twice as much energy as do equal por-ons of either carbohydrates or proteins. Moreover, the greatest pply of reserve energy in animals and man is found in the fat stores the body which may be mobilized to meet the body's need for nergy in times of dietary caloric shortages.

Source of fat-soluble vitamins. There are four vitamins that we now are carried by the fats in the food. This group is referred to as e fat-soluble vitamin family and includes vitamins, A, D, E, and K. detailed presentation of the fat-soluble vitamins can be found in hapter 13.

Source of essential fatty acids. Although it is known that fatty cids can be synthesized from extra amounts of cabohydrates in the ody, there are certain fatty acids which man needs for good health at the body cannot produce. These are called the *essential fatty cids* and include the following three acids, linoleic, linolenic, and rachidonic. The importance of these factors in nutrition was first emonstrated when rats fed a ration devoid of fat developed a scaly ondition of the skin and tail, failed to grow, and eventually died Fig. 9). All the known fatty acids were added to the fat-free diet the animals but only linoleic, linolenic, and arachidonic acids were ffective in preventing this disorder (*3*). It now appears that a

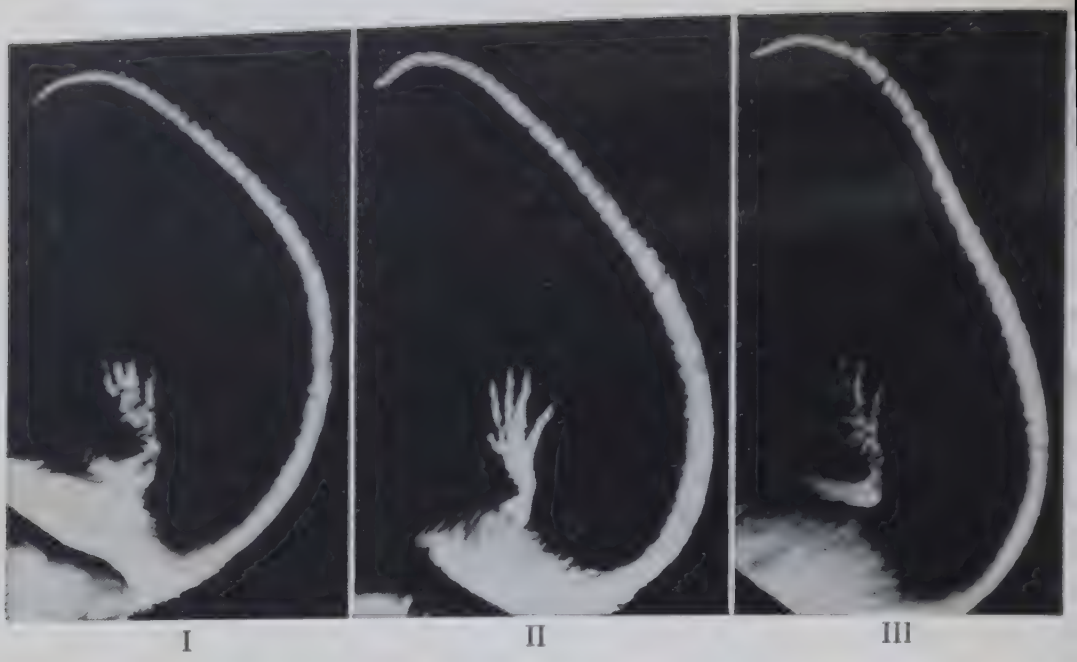


Fig. 9. The scaly condition of the skin and tail of a rat fed a low fat diet and the effects of humidity on the skin lesions. I. Low fat rat from colony. II. Same animal after 48 hours at 97 per cent relative humidity. III. Same animal after 3 weeks at 50 per cent relative humidity. (Courtesy of Burr, Experimental Station, H.S.P.A.)

dietary source of the essential fatty acids is required by the mouse, the dog, and man also.

Little is known about the essential fatty acid requirement of man. Although attempts to produce a fat deficiency have not been successful, a tendency toward skin disorders is a characteristic response to a low fat diet in infants (*4*). It is known from studies with normal, healthy children that there is no dietary requirement for arachidonic acid when linoleic acid is supplied in optimal amounts (7). Some cases of infant eczema were found to result from an essential fatty acid deficiency. Skin conditions in children have been improved with the feeding of lard which, along with margarine and butter, is known to be a rich source of the essential fatty acids (Table 1).

Production of a satiety effect; protection of the body. A factor in favor of adequate fat in the diet is the satiety effect produced by this nutrient. Fats are digested and absorbed in the body more slowly than either carbohydrates or proteins; as a result fat foods delay the feeling of hunger for a longer length of time than carbohydrates or protein.

Fats are known to protect the body in two ways. The deposits of

Table 1. Typical Fatty Acid Analyses of Some Fats of Animal and Plant Origin

(All values in weight percentages)

	Saturated			Unsaturated		
	Palmitic	Stearic	Other*	Oleic	Linoleic	Other
IMAL FATS						
rd	29.8	12.7	1.0	47.8	3.1	5.6†
icken	25.6	7.0	0.3	39.4	21.8	5.9†
tterfat	25.2	9.2	25.6	29.5	3.6	7.2†
ef fat	29.2	21.0	3.4	41.1	1.8	3.5†
GETABLE OILS						
rn	8.1	2.5	0.1	30.1	56.3	2.9
anut	6.3	4.9	5.9	61.1	21.8	...
ttonseed	23.4	1.1	2.7	22.9	47.8	2.1
y bean	9.8	2.4	1.2	28.9	50.7	7.0‡
ive	10.0	3.3	0.6	77.5	8.6	...
conut	10.5	2.3	78.4	7.5	Tr	1.3

From *The Role of Dietary Fat in Human Health*, Natl. Acad. Sci., Natl. Research uncil Pub. 575, 1958.

* Values in this column for butterfat and coconut oil are due to large amounts acids C_{12} and below. Peanut oil contains several per cent of C_{20} and above acids.

† Mainly hexadecenoic acid; 0.2–0.4% arachidonic acid.

‡ Mostly linolenic acid.

t under the skin act as nonconductors of heat, helping to insulate e body and prevent the rapid loss of heat. Furthermore, the viscera nd certain organs of the body such as the kidneys, are supported and ushioned by fat.

oncepts of the relationship of dietary fat to atherosclerosis

There is a great deal of interest now in the causes of *atherosclerosis*, disease in which the walls of the arteries become narrowed due to eposits of fats and mineral salts. It is believed that the atherosclero- c condition in man makes him more susceptible to heart attacks and rokes. In part the basis for the present theories on the relationship f dietary fat to atherosclerosis and thus to heart disease originated ith the observations made in Norway during the years of the Second Vorld War as well as to more recent inter-racial studies made in other arts of the world. In Norway, when the fat content of the diet was arkedly reduced by wartime rationing, the incidence of atherosclero-

sis was also greatly reduced. Moreover, atherosclerosis is not prevalent in countries of the world such as Japan, Spain, Italy, or parts of Africa where the total Calories of the diet derived from fat are much lower than those in the average American diet.

Because the incidence of atherosclerosis has been associated with high values of *cholesterol* in the blood, it has been assumed to be one of the causes of the disorder. Cholesterol, a fatlike substance, is found in all animal fats and oils. During the last ten years, many studies have been conducted to discover how dietary fat affects the blood cholesterol in both animals and man. In order to become familiar with the theories that have been presented on this problem, a resume of some of the important findings at this time are presented. At first, it was believed that the cholesterol level of the blood was directly related to the cholesterol content of the foods in the diet. This theory, however, was disproved when the ingestion of cholesterol itself was shown not to increase blood cholesterol (*1*). Then it was suggested that the amount of fat in the diet might be responsible for the elevation of cholesterol in the blood. Yet, it appears that total quantity of fat is not the key to the problem because the ingestion of animal fats only was found to increase the blood cholesterol when equal portions of animal or vegetable fats were fed separately (*1*). A theory advanced is that the amount of saturated fatty acids in the fat of the diet may be the factor responsible for the increase in the cholesterol level of the blood. It has been shown that the ingestion of saturated fats such as animal fats and hydrogenated vegetable fats by human subjects caused an increase in the blood cholesterol, whereas intakes of equivalent amounts of unsaturated fats, such as olive oil and fish oils, had a reverse effect on the cholesterol of the blood (*2*). The opposing effects of saturated fatty acids and unsaturated essential fatty acids on blood cholesterol levels has been observed in clinical experiments (*6*). Although many theories have been advanced on the relationship of fat in the diet to the level of blood cholesterol, at this time, there is no conclusive evidence to substantiate a claim that atherosclerosis and thus heart disease can be attributed to the cholesterol content of the diet, to the amount of fat, or to the nature of fat in the human diet.

Recommended Allowances for fat

Little is known about the fat requirement of man, and for this reason allowances for this nutrient have not been recommended by the National Research Council. It is suggested that if 20 per cent of the total dietary Calories come from fat there will be adequate amounts

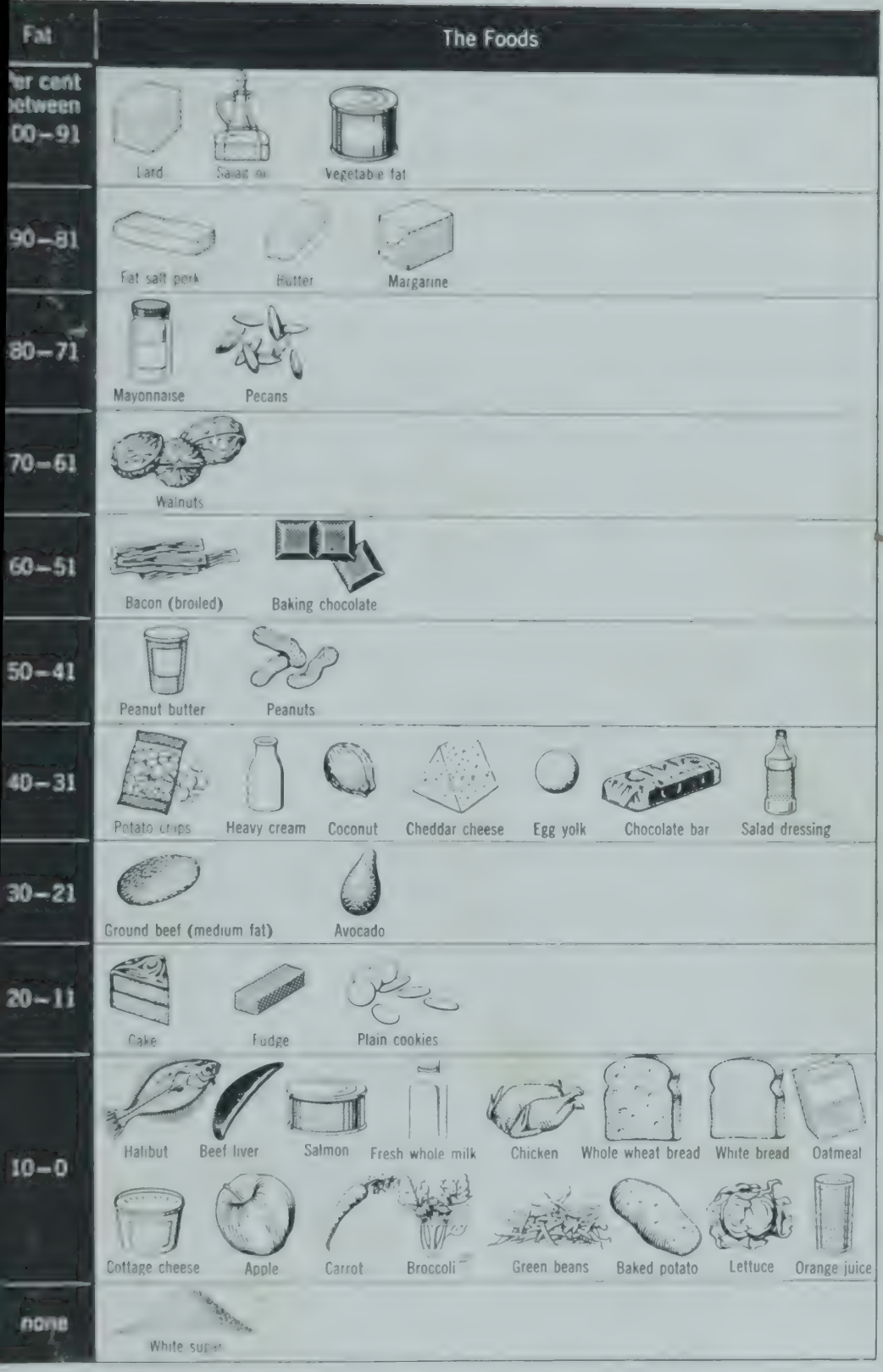


Fig. 10. The percentage of fat in some typical foods.
Adapted from values in *Composition of Foods*—Raw, Processed, Prepared. U.S. Department of Agriculture; Agriculture Handbook 8, 1950.

of the essential fatty acids present to meet physiological needs of the body.

The U.S. Department of Agriculture reported for 1957 the per capita consumption of fats and oils (table fats, shortening, fat pork and other edible oils) was 1.25 pounds per week (5).

Food sources of fats

The richest sources of fat in the diet are the vegetable oils such as corn oil, peanut oil, olive oil, and vegetable shortenings and the animal fats such as lard and butter (Fig. 10). Nuts rank high as contributors of fat to the diet, with pecans having the most, peanuts the least. Meat, poultry, and fish vary in their fat content; bacon contains about twice as much as beef and salmon (an example of a fatty fish). All cheeses with the exception of cottage cheese contain appreciable amounts of the nutrient. The fat in an egg is found only in the yolk. Processed and prepared foods made with fats and oils such as potato chips, cakes, pastries, cookies, and candy bars may contain appreciable amounts of the nutrient. Most fruits and vegetables are poor carriers of fats, however, there are two exceptions, the avocado and the coconut contain more than 25 per cent fat.

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HAPTER 5

The proteins

The word *protein*, derived from the Greek language, means "to
ne first." Mulder, the famous Dutch chemist (1802–1880) proposed
of the term for he believed that the proteins were "unquestionably
most important of all known substances in the organic kingdom."
ne has affirmed that Mulder's choice of a name was rightfully
en.

The early chemists sought to learn something of the nature of
getable and animal substances by submitting the samples to distil-
on. Thus the invention of a "steam digestor" by the French
ysicist Papin (1647–1712) prepared the way for the study of protein,
he invented the apparatus to soften bones in order to extract
atin from them (*13*). The *jelly* from bones and meat also, at-
cted the attention of scientists; they considered it "the true animal
ostance." The term *albuminous* was used to designate *animal*
tter. Mulder was the first to propose a theory that all albuminous
ostances contained a common structural unit which he called *protein*.
ebig (1803–1873) supported the view of Mulder.

These and many other studies of early scientists lead the way for
advances that followed in the nineteenth century and in the
rrent era.

Protein is one of the most abundant components in the body. It is
eeded in amount by one other compound only, and that is water.
e major portion of the protein is located in muscle tissue; the re-
inder is widely distributed in blood, other soft tissues, bones, and
th.

The chemical elements found in each protein are carbon, hydrogen,

oxygen, and nitrogen. Also, sulfur is present in many of the molecules; phosphorus, iron, iodine, and cobalt are found in some of them. Of the elements present in protein, nitrogen is the distinguishing one; it does not occur in fat and carbohydrate, and is always present in protein.

The number of different proteins found in nature is infinite. They vary from tissue to tissue within the plant or animal, and in the corresponding tissues among different species. Within a species the same proteins are synthesized by all members. Protein specificity is the term applied to the property of proteins of being characteristic of the animal species in which they occur.

The Amino Acids

All proteins are made up of amino acids, which are simple units, often termed for the sake of clarity "building stones" of protein. As the name suggests, amino acids are compounds that contain amino groups ($-NH_2$) and carboxyl or acid groups (-COOH). A diagrammatic drawing of the chemical structure of the amino acid tryptophan is shown in Fig. 11.

Most food proteins are comprised of 12 to 20 amino acids linked together in one large molecule. They may be the same or different amino acids. Some proteins, however, may have as many as 280 amino acids in a single molecule. Listed below are 22 of the amino acids that occur commonly in foods and in body constituents:

alanine
arginine
aspartic acid
cystine
glutamic acid
glycine
histidine
hydroxyglutamic acid
hydroxyproline
isoleucine
leucine
lysine
methionine
norleucine
phenylalanine
proline
serine
threonine
thyroxin
tryptophan
tyrosine
valine

We should be aware that the above list is not exhaustive. There are many more amino acids, but they have less recognized significance in nutrition at present.

Amino acids are white crystalline substances, each with an individual microscopic structure. The amino acids differ in taste; some are sweet, (glycine, alanine, and serine), some are tasteless (tryptophan and leucine), others are bitter (arginine).

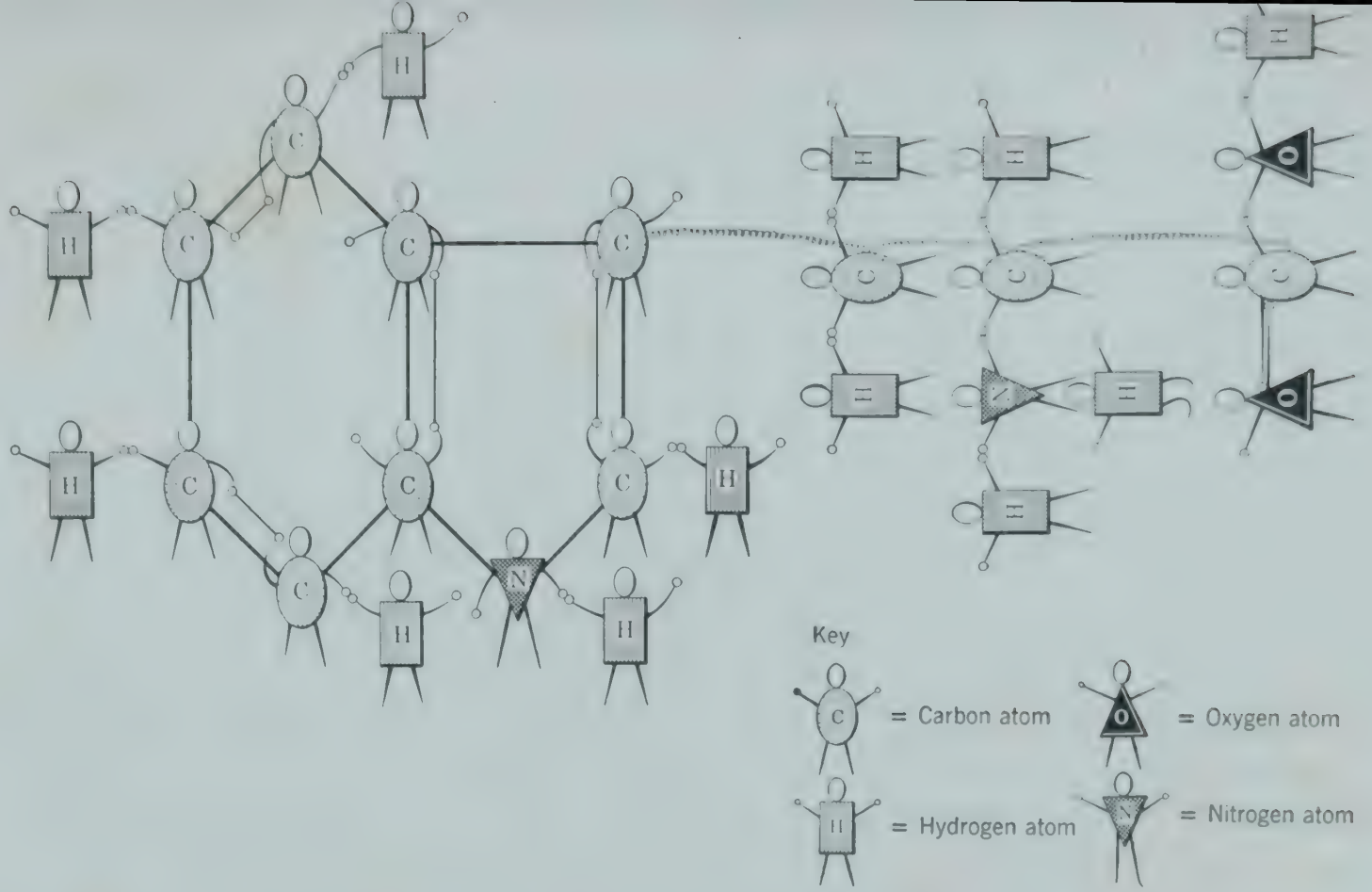


Fig. 11. Diagrammatic representation of the chemical formula of the amino acid, tryptophan.

Functions of Protein

An important function of dietary protein is the provision of amino acids for the body for the building of new tissue and the maintenance of the tissue already formed. In addition, it provides the necessary constituents for the formation of nitrogen-containing substances essential to body function, such as the enzymes and some of the hormones. Protein serves also in certain body regulating capacities and can be used to provide energy.

Body building substance

Protein is present in every cell in the body. The nature and behavior of protein in cells of various tissues differ, contributing to each certain distinguishing characteristics. The protein in muscle has, for instance, the capacity of holding fluid, which gives to that tissue a certain firmness, even though composed of 75 per cent or more of water. Protein in epithelial tissue is hard and insoluble, providing a protective covering for the body; in the walls of the blood vessels, the protein there contributes elasticity, which is an essential characteristic for the maintenance of normal blood pressure. The mineral matter of bones and teeth is embedded in a framework composed of protein. The above functions, and others, demonstrate the significant and specific role of protein as a tissue building substance.

The need for protein for building new tissue and upkeep and repair of old, is continuous throughout life. It is, of course, the young for whom the need for new tissue is greatest, but there is a continuing minimal need for the adult also. The hair and the nails continue to grow; the outer layer of skin scales off and is replaced. In pregnancy there is need for the formation of new tissue in the developing fetus and certain tissues of the mother.

Research scientists are discovering how the synthesis of protein takes place in the tissues. It has been a mystery that has challenged investigators for a long time. The preparation of amino acids in which the carbon or nitrogen is radioactive has made possible findings that could not have been discovered otherwise. Amino acids "tagged" with radioactive elements can be followed throughout the body and distinguished from those already present in the body which normally have no radioactivity. From such ingenious studies we have learned that the amino acids released from the degraded proteins are replaced by new ones from the blood, in a continuous interchange between tissue and blood (*1*, *14*). We know too that for a particular protein to be synthesized, all of the amino acids needed for its formation must

vailable simultaneously and in the proportion required (5, 7). If
one of the amino acids needed is missing in the diet, or the
unt provided is insufficient, growth failure occurs in the young.
he adult, if the amino acid is not available when needed, body
ue is broken down in an effort to supply it.

The necessity of having available simultaneously all amino acids
ntial for the synthesis of tissue proteins has practical implications
he planning of diets. If the protein and caloric intake are limited,
ter use of protein is realized by providing a source of protein that
plies all of the amino acids needed for tissue formation (complete
tein) such as meat, milk, or eggs, at each meal of the day.
a study with college women whose diets contained 43 gm of protein
gm—Recommended Allowance) and 1950 Cal. (2400 Cal.—
commended Allowance), more nitrogen was retained in the body,
icating better use of the dietary protein, if in all three meals a
rce of complete protein was included (*12*). If the protein and
energy intake were adequate, omission of a source of complete
tein at one of the day's meals made less difference.

cursor of enzymes, hormones, and antibodies

ome of the compounds essential in vital processes in the body are
ived from amino acids. In this group of nitrogen-containing com-
nds are the body enzymes, including the digestive enzymes and
se that function in processes of oxidation in the tissue cells. Some
the hormones are nitrogen-containing compounds; among them are
lin, thyroxine, adrenalin, the hormone of the parathyroid gland,
certain of the secretions of the pituitary gland.

Still another protein compound of particular significance is gamma
bulin, a normal protein in the blood which has been identified
n antibody. Animals subjected to prolonged protein undernutrition
ibit a pronounced loss of ability for manufacturing antibodies and
nsequently are less able to resist infection. The antibody producing
acity is quickly restored when adequate amounts of high quality
teins are ingested. Cannon (*4*) who did the major research on
mma globulin suggested that increased susceptibility to infection
wn by starving persons is likely attributable to protein depletion
the consequent inability to produce new supplies of antibodies.

dy regulating substance

Movement of fluid. Protein is one of the factors that contributes
the control of the movement of fluids in and out of cells, and to and

from the blood stream, by contributing to the osmotic pressure of the body fluids in which it occurs. The large size of the protein molecule prevents its passage through membranes, whereas water and materials in solution pass readily. The fluid moves from a medium of lesser concentration of substances such as protein that cannot pass through the body membranes to one of greater concentration; the process is osmosis. The movement of fluids by the process of osmosis is one of the means the body has of maintaining normal composition of the blood and other body fluids.

Maintenance of normal reaction in the tissues. There are several mechanisms for maintaining a normal balance between acidic and basic substances in the body. It is sufficient to indicate at this point that protein functions in this important regulatory mechanism through its buffer action.

Source of energy

When the carbohydrate and fat content of the diet is insufficient to meet the body's need for energy, protein is then used for that purpose. Even though we consider protein primarily as a body building and body regulating substance, when it is needed for energy that function takes precedence over the other two.

The nonnitrogenous portion of the protein molecule is the part that is used for energy. There are several pathways that this fraction may take; it may be oxidized directly, or converted to carbohydrate or fat. Also it may be changed back to certain amino acids (the nonessential amino acids) by adding an available amino group. This is one means by which amino acids can be made in the body. As for the nitrogen removed from the protein, most of it is eliminated as waste by way of the kidney. (Further discussion of protein metabolism in Chapter 6.)

Protein Deficiency

Insufficient protein in the diet results in stunted growth in the young. The growth effect is readily demonstrated in experimental animals by feeding a diet deficient either in quantity or quality of protein. Farmers and stock feeders are well aware of the necessity of providing adequate protein for the best growth of their livestock. If the limitation is severe and prolonged, the protein content of the blood may be reduced below normal (hypoproteinemia) (2).

A severe deficiency disease, *kwashiorkor*, found among the children of Africa and parts of Central and South America is caused by a

tage both in total amount of protein and of protein of good lity (*20*). It is most prevalent in populations whose protein ply is chiefly of vegetable origin. If the diet is inadequate in tein it is most certain to be so in other nutrients also; the condition been described as a "multiple deficiency syndrome" for that on. Children between the ages of one and 4 years are most mmonly afflicted, although sporadic cases do occur among older dren also.

The children suffering with kwashiorkor manifest certain charristic symptoms. They are stunted in growth. The skin shows perpigmentation and is frequently ulcerated. The children are thetic showing marked lassitude; even so they are irritable and rest-. The digestive system is impaired by the diarrhea that is always sent. The children have poor appetites; anemia is always present; incidence of dental caries is high; the muscles are underdeveloped lacking in tone. Children suffering with kwashiorkor are shown Fig. 12.

Treatment of the disease is essentially dietary. Sources of good lity protein such as skim milk and other animal proteins have been ective in alleviating the condition. In Central America, a discussion preventive measures for the disease resulted in the following sugtions: that varieties of maize higher in methionine and tryptophan



12. African children with typical symptoms of kwashiorkor. (Courtesy orld Health Organization, Monograph Series 8, Geneva Switzerland.)

content be developed; that the production be increased of certai protein-producing plants now being consumed, such as beans, and th use of soybean milk be promoted to substitute for milk, which unavailable to the populations in those areas.

The Nutritional Value of Proteins

Proteins differ in their nutritive value, due to the difference i their amino acid content. This was demonstrated in the classi studies of Osborne and Mendel at Yale University in which singl proteins were fed to young albino rats as the only source of th nutrient. Certain of the proteins could not support growth of th young animals (gliadin of wheat and rye), and others not only did not support growth, but failed even to maintain weight (zein of corn). Addition of the amino acid, lysine, to the ration containing gliadi resulted in the resumption of growth in the animals. Addition of th amino acid, tryptophan, to the ration containing zein permitted maintenance of body weight. The addition of both tryptophan and lysine to the zein ration made possible satisfactory growth.

On the basis of studies such as those of Osborne and Mendel and others, a classification of proteins based on nutritive quality was proposed.

Complete proteins maintain life and provide for normal growth of the young when used as the only protein in the diet of experimental animals. As a general rule, the proteins of animal source are complete, including those of meat, fish, fowl, eggs, and milk; gelatin is an exception. The protein glycinin of soybeans is complete, as is the glutenin of wheat and the glutelin of corn. The protein excelsin in Brazil nuts and almonds is complete.

Partially incomplete proteins maintain life but fail to support normal growth. Examples include gliadin of wheat, hordein of barley, and prolamin of rye.

Incomplete proteins neither maintain life nor support growth. Most vegetable proteins are incomplete; the glycinin of soybeans is an exception. The zein of corn and the animal protein, gelatin, are incomplete.

The above classification is not absolute. When limited quantities of complete protein are fed, the response is like that of the partially incomplete in that failure to grow results. Cereals as a source of complete protein illustrate this point. Wheat, for example, contains a complete protein, also one that is incomplete. Although each of the grains is a source of complete protein the amount is relatively

l, making it impossible to consume enough of the grain alone to vide an adequate intake of protein of good quality.

ntial amino acids

y 1938 a new type of study became possible for assessing the ritive value of proteins. Instead of feeding proteins as in the Os- ne and Mendel studies (1911–1924), a mixture of chemically pure no acids was used. This kind of study could not have been con- ted, of course, until the amino acids found in proteins had been ated. As many as nine new ones were identified during the inter- ing years between 1924 and 1938. Rose of the University of nois pioneered in these early classical studies using young albino as the experimental animal. In order to assess the nutritional ue of each amino acid, one by one they were omitted from the ture and the effect on growth observed. When certain amino ds were removed, growth was impaired; the omission of others had effect. There were ten amino acids found to be essential in the ; the body was unable to synthesize them at a rate sufficiently rapid provide for the needs of growth. They are called "essential" or dispensable" amino acids, indicating that they are essential in the . The ten amino acids essential for growth of young rats are ed in Table 2. Those amino acids not needed in the diet are the s the body is able to synthesize at the rate needed. They are gnated as "non-essential" or "dispensable."

After the identification of amino acids essential for growth in young , the next question naturally concerned the need of the human ng for specific amino acids. Rose again pioneered, this time in dies with the human being; graduate students served as subjects. e experimental diet bore little resemblance to our customary meals, still was adequate in nutrient content. A mixture of pure amino ds supplied the protein content of the diet; the remainder of the d was free of all protein. The complete diet consisted of the amino ds, cornstarch, sucrose, corn oil, inorganic salts, and vitamin con- trates. One by one the amino acids were removed from the mix- e as in the earlier studies, and the effect on the *nitrogen balance* was erved. In the nitrogen balance procedure,[1] the intake of nitrogen etermined quantitatively by analysis of the food eaten, and the ex- ion of nitrogen by analyses of the fecal and urinary excretions. he removal of an amino acid from the mixture resulted in a greater retion than intake of nitrogen, it was an indication that the amino

[1] Further discussion of the details and significance of the balance study follow he subsequent section, "The Requirement of Protein and Amino Acids."

acid was *essential* for the adult and the body could not synthesize it at the rate needed. If the balance was unchanged by the removal of an amino acid, that particular amino acid was considered nonessential. With the exception of arginine and histidine, the amino acids needed for the growth of the rat are also essential for man to prevent loss of nitrogen from the body. The eight amino acids essential in the diet of adult men are isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine (Table 2).

Table 2. Amino Acids Essential for Growth in the Young Rat and for Maintenance in Adult Men

Amino Acids	Essential for Growth in Young Rats	Essential for Maintenance in Adult Men
Arginine	x	
Histidine	x	
Isoleucine	x	x
Leucine	x	x
Lysine	x	x
Methionine	x	x
Phenylalanine	x	x
Threonine	x	x
Tryptophan	x	x
Valine	x	x

The terminology of *nonessential* as applied to amino acids should not minimize in our attitudes the importance of these amino acids in the body. It simply means that they need not be provided "ready-made" in the diet; the body can supply them as it needs them. To justify their importance, we may point out that they comprise 40 per cent or more of the tissue protein. When they are supplied in the food intake, as they always are in an ordinary diet, less of the essential acids are needed. The nonessential amino acids can supply nitrogen for the synthesis of some body compounds for which the essential amino acids would otherwise be used.

Digestibility of proteins

Fundamental to the nutritive value of a protein, in addition to the amino acid composition, is the digestibility. Proteins from the animal group of foods are the most available for absorption, those from dried legumes least available because of less complete digestion (Table 3).

le 3. Average Digestibility of Proteins from Different Food Groups

Food Group	Coefficients of Availability,* per cent
Animal foods	97
Cereals	85
Fruits	85
Vegetables	83
Legumes, dried	78

om Atwater, W. O., and A. P. Bryant, *12 Ann. Rept. Storrs Agr. Exp. Sta.*, ersity of Conn., 1899, p. 73.
Approximations for an average mixed diet.

ne digestibility of a given protein is influenced not only by the content of the food containing the protein but also by the unt of fiber in the remainder of the diet (*10*). There are several ons for the interfering effect of fiber on digestion. Motility of gastrointestinal tract is increased by the presence of fiber; the rapid movement of the intestinal content along the tract shortens time for digestive enzymes to act. Also, it is presumed that lose may further detract from the completeness of digestion reventing the protein from coming in contact with the digestive mes.

The Supplementary Value of Protein

ods differ in the nutritive value of the protein they contain. food, with the exception of gelatin, contains more than one kind rotein, each with a characteristic number and concentration of o acids. The proteins of some foods contain limited amounts ertain essential amino acids, generous amounts of others. As a equence, a combination of foods such that the amino acids con- d in the proteins supplement each other, is of higher nutritive ty than either alone. Early studies with experimental animals onstrated that the proteins of cereals and those of milk have a lementary effect. The proteins of milk are superior in quality. of cereals are less efficient. Nevertheless, the cereal and milk ogether in the right proportions, with cereals replacing some of nilk, were as effective as milk alone. Cereals are limited in lysine; provides it generously.

examination of the table of amino acid content of foods (Ap-

pendix, Table A-6) shows possibilities of combining foods so that the amino acids contained may supplement each other. For example, tryptophan is limited in amount in corn and white flour, whereas foods of animal origin provide tryptophan generously. Two-thirds cup of cooked corn meal (25 gm dry) contains 0.056 gm of tryptophan, whereas a serving of pork, chicken, or beef provides approximately four times that amount. Legumes (beans and peas) are deficient in tryptophan and methionine and need to be supplemented by animal protein.

As more complete analyses are available, further possibilities of supplementation will be realized. We cannot draw final conclusions on the supplementary value of certain proteins, however, until we know how well the human is able to use the amino acids in different foods. The use of protein combinations to improve the nutritional quality of the diet holds greatest significance for persons living in parts of the world where foods of animal origin are scarce, and the diet is chiefly cereal.

The Requirement for Protein and Amino Acids

Method of study

The method commonly used in determining protein requirement is the nitrogen balance study. One of the steps in the procedure for nitrogen analysis is shown in Fig. 13. The nitrogen values can be converted to protein by multiplying by the factor 6.25 because, on the average, food proteins are 16 per cent nitrogen. In determining the nitrogen balance, the nitrogen content of the food eaten and of the urinary and fecal excretion are determined quantitatively. The findings are interpreted in this manner: if the intake of nitrogen exceeds the outgo, the retention of nitrogen in the body is designated as a *positive* balance. If the outgo is greater than the intake, the loss of nitrogen is termed a *negative* balance. When the intake and outgo are approximately the same, the individual is said to be in nitrogen *equilibrium*. The lowest nitrogen intake that will permit a state of nitrogen equilibrium is considered the *minimum* nitrogen (protein) need.

Factors influencing minimum protein need

Among the factors influencing the nitrogen balance are (*a*) the physiological state of the individual, (*b*) adequacy of energy intake from carbohydrate and fat, and (*c*) the capacity to adjust to level



13. Analyzing food for nitrogen. (Courtesy of Swift, Institute of Animal rition. The Pennsylvania State University.)

ntake. The amount of protein required in the diet to maintain ilibrium varies with the state of the nitrogen stores. As the ted amounts that can be stored are progressively depleted, dietary ogen is utilized more efficiently. When consuming a diet com- ble in nitrogen content a malnourished person retains more than who is well-nourished (*16*). Certain physiological conditions in- se the need for protein. During pregnancy and during child- d there is need for nitrogen for building new tissue; as a con- uence at those periods the balances are normally positive.

The adequacy of the energy intake makes a difference in the unt of protein required. If the carbohydrate and fat content of diet are sufficient to take care of the energy requirement, protein l not be used for that purpose. Sparing protein the necessity of g used for energy is called the *sparing effect* of carbohydrate and

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fat. There have been many investigations of the comparative effectiveness of carbohydrate and fat in their sparing action (15, 19). From experimental studies with animals on a restricted caloric intake it now appears that on a calorie basis carbohydrate and fat are used equally well, if some of each is present in the diet.

The body, with its profound capacity for adaptability tends to maintain nitrogen equilibrium in an adult even though the intake may vary widely. When the intake is lowered, the excretion decreases also, chiefly in the urine. The converse takes place when the intake is increased; the excretion likewise increases. Table 4

Table 4. The Effect of Extremely Low Protein Intake on Nitrogen Excretion

Days on diet	Average daily nitrogen intake in gm	Average daily excretion in gm	
		Urine	Feces
7	Unrestricted diet	12.03	1.03
6	0.27	4.85	0.85
7	0.77	3.55	0.73
8	0.94	2.21	0.83
4	0.32	1.41	0.89
2	Unrestricted diet	9.21	. . .

Adapted from Smith, *J. Biol. Chem.* **68**: 15, 1926.

shows the adaptation made by an individual whose diet was changed from one providing an unrestricted intake amounting to approximately 75 gm of protein daily to one almost protein free. On an unrestricted protein intake the nitrogen excretion in the urine was approximately 12 gm; after 4 days on an almost protein-free diet the excretion was reduced to 1.41 gm nitrogen.

Increased need for protein under conditions of stress

After surgery or injury, during a wasting illness, or recovery from extensive burns, excessive loss of nitrogen from the body occurs. It is generally felt that these losses should be replaced through a liberal intake of protein.

Influence of exercise on protein need

It is unexpected perhaps that exercise does not increase the protein need. If the caloric intake is sufficient to cover the increased energy requirement during exercise, little, if any additional protein is needed. The finding is logical because during exercise glycogen is the ultimate

stituent used up in muscle contraction and not protein. The data Table 5 is from an early experiment in which a subject was maintained on the same nitrogen intake with adjustments in energy intake ake care of different degrees of exercise. No increase in the excretion of nitrogen resulted with exercise, reflecting no additional d for protein.

Table 5. Influence of Work on Nitrogen Excretion

Activity	Period, days	Food/day Nitrogen, gm	Food/day Energy, Cal.	Nitrogen excreted, daily average, gm
rest	6	5.9	2300	4.77
t exercise	5	6.0	3000	4.40
y exercise	4	5.9	3200	3.94

dapted from Shaffer, *Am. J. Physiol.* **22**: 445, 1908.

ommended Allowance for protein

or young men and women 16 to 20 years of age, the Recommended wance is 100 gm per day for young men, and 75 gm per day for ng women. For adults, the recommendation is one gm per kg of y weight. Around 10 to 12 per cent of the total Calories are from ein in diets that are adequate in this nutrient. The needs for ncy, childhood, and during pregnancy and lactation are discussed ose respective chapters.

ndings from nitrogen balance studies are the basis for the recomded daily intake. However, when the quantitative findings on ch the original recommendations were made are examined, we that an average intake of approximately 0.6 gm per kg of body ght was the minimal amount sufficient for maintenance of nitrogen librium in normal adults. Sherman, who did the earlier work, posed that an *allowance for safety* be added and recommended that daily intake be increased to one gm per kg for normal adults.

here is a growing feeling among nutritionists, who now have the ntage of more recent studies, that the protein need may be less was previously supposed. In a study with college women (*3*) e University of Illinois, nitrogen equilibrium was maintained at an e of 0.55 gm per kg even though the protein in the diet was ominantly from cereal sources. Also in a study done by Heg- and his coworkers of the Harvard School of Public Health, gen equilibrium in healthy adults was possible on intakes from

0.43 gm to 0.57 gm per kg with cereals, vegetables, and fruits providing the protein (*11*). Replacing one-third of the protein in the diet with protein of animal sources, made it possible to maintain equilibrium at an intake of only 0.39 gm per kg.

An interpretation of protein need

To summarize certain aspects of the daily protein need, in the first place, a generous allowance for protein is justified in that it provides for individual differences in need and differences in the quality of proteins in the diet. On the other hand, there is evidence that the body adjusts to the intake and that nitrogen equilibrium can be maintained on amounts much lower than the Recommended Allowance, as well as much higher. From the practical standpoint the capacity of the body to maintain equilibrium at a lower intake is reassuring, for in parts of the world the more generous allowance is wholly unattainable.

The quantitative need for amino acids

After it was established that adult man needs certain amino acids for maintenance of nitrogen equilibrium, the next step was to study the amount of each acid needed daily. Sufficient research (*17, 18*) has been done with both women and men that quantitative amounts needed daily can be indicated as summarized in Table 6.

Table 6. Minimum Amounts of Essential Amino Acids Required Daily for Maintenance of Nitrogen Equilibrium in Adults

Essential Amino Acid	Women, gm	Men, gm
Isoleucine	0.45	0.70
Leucine	0.62	1.10
Lysine	0.50	0.80
Methionine	0.29	1.10
Phenylalanine	0.22	1.10
Threonine	0.31	0.50
Tryptophan	0.16	0.25
Valine	0.65	0.80

Adapted from Reynolds, M. S., *J. Am. Dietet. Assoc.* **33**: 1016, 1957.

In considering the practical use of this information, we bear in mind that for the most part pure amino acids were used in these studies.

Table 7. Essential Amino Acid Composition of Certain Food Proteins

Food	Isoleucine, gm	Leucine, gm	Lysine, gm	Methionine, gm	Phenylalanine, gm	Threonine, gm	Tryptophan, gm	Valine, gm
100 gm beef round	1.02	1.60	1.70	0.48	0.80	0.86	0.23	1.08
1 egg	0.42	0.56	0.41	0.20	0.37	0.32	0.10	0.48
1 pt milk	1.09	1.68	1.33	0.42	0.83	0.79	0.24	1.17
Total	2.53	3.84	3.44	1.10	2.00	1.97	0.57	2.73
Minimum requirements for men	0.70	1.10	0.80	1.10	1.10	0.50	0.25	0.80

From Amino Acid Content of Foods, U.S. Dept. Agr., Home Economics Research Report No. 4, 1957.

with very little natural food. Whether similar amounts of the amin acids provided in foods would serve equally well, we do not know yet. Rose, who proposed the *minimum* daily need of the essenti amino acids from his research studies, has suggested that the *saf* amount should be twice the minimum values.

Supplying essential amino acids

It is not difficult to provide the essential amino acids at the minimum level for maintenance for adults if the diet includes animal proteins The combined contribution of 100 gm of beef round, 1 egg, and 1 p of milk generously exceeds the minimum requirement for adult (Table 7). We do not have information as yet on how efficiently amino acids can be used by the human. Work with experimental animals shows that there is a difference in the efficiency with which the amino acids in a food are used, and also a difference in the availability of the same amino acid in different foods (*8*).

Table 8. Essential Amino Acid Content of the "Average" American Diet Compared with "Safe" Levels for Men

Essential Amino Acid	"Average" American Diet, gm/day	"Safe" Levels for Men, gm/day
Isoleucine	4.2	1.40
Leucine	6.5	2.20
Lysine	4.0	1.60
Methionine	3.0	2.20
Phenylalanine	4.1	2.20
Threonine	2.8	1.00
Tryptophan	0.9	0.50
Valine	4.2	1.60

From Reynolds, M. S., *J. Am. Dietet. Assoc.* **33**: 1017, 1957.

Some consideration is being given to adding the essential amino acids that are supplied in limited amounts in commonly used foods such as cereals, in an effort to improve their nutritional quality as a source of protein. The idea is viewed with skepticism by some nutritionists (*6*). The average American diet appears at present to provide the essential amino acids adequately without fortification of foods. The estimated essential amino acid content of the average diet exceeds even the *safe* level which is twice the minimum need for maintenance

he adult (Table 8). We must bear in mind, however, that the age diet in the year 1959 is one that is high in protein content e possible by the general high level of purchasing power among people and an abundance of food available.

nother reason, and one more fundamental for delaying the ption of amino acid fortification of foods, is that the addition ht bring about an imbalance in the relative proportion of amino ds (9), a complex dietary problem as yet incompletely clarified. We know, however, from studies with experimental animals that the ition of one amino acid may alter the need for others, and instead achieving the desired effect of improved well-being, the animal be less well off than without the addition. On the other hand, ification of foods with amino acids may be found, with further dy, to be a desirable way of providing more protein of good lity. If the process should prove to be practical, the people of ny parts of the world where a lack of adequate protein is a serious ary problem would benefit.

Food Sources of Protein

rotein is widely distributed in nature, but with few foods provid- highly concentrated amounts. Gelatin, dried nonfat milk solids, dried beef are high in per cent of protein; a contributing factor he low water content of the foods (Fig. 28). Cheese, eggs, fish, ts, nuts, and poultry are the primary sources of protein even ugh the range in content is only 12 to 29 per cent. Cereal grains second as protein contributors to the diet. Fruits and vege- es are low-protein foods. The only foods containing no protein the sugars and syrups, and the fats and oils. The per cent of tein in some typical foods is shown in Fig. 14.

nimal foods provide protein high in nutritive quality and in unts that make them first in order of importance. That knowl- e should not minimize our appreciation of the role of plants in viding protein. Soybeans and some nuts, Brazil and almonds, tain protein of good quality; most cereals provide a limited unt of good quality protein. In addition, plants are fundamental he provision of animal proteins for human consumption. Nature equipped plants with the capacity to use nitrogen available in soil for the synthesis of amino acids and protein. Ruminant nals consume the proteins in plants and are able to use them as urce of nitrogen for the synthesis of their tissue proteins.

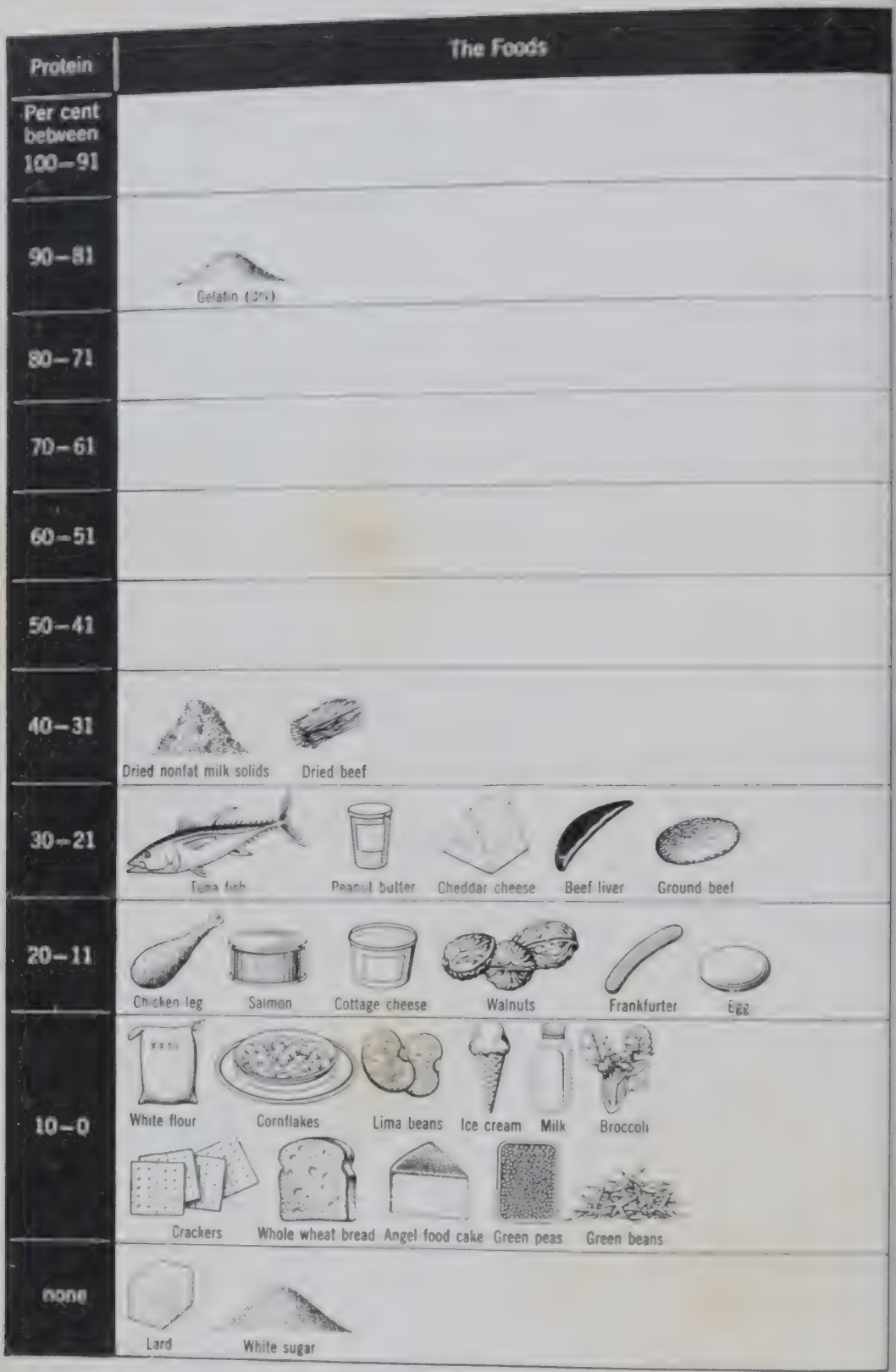


Fig. 14. The percentage of protein in some typical foods. Adapted from values in *Composition of Foods. Raw, Processed, Prepared.* U.S. Department of Agriculture, Handbook 8, 1950.

ıide to the selection of foods to meet the protein ds of college men and women

practical approach to assuring an adequate provision of protein ıe diet each day is to include certain types of foods. It does not n, however, that such a pattern is inflexible; it merely means that useful as a guide. Such a pattern includes 1 pt or more of milk, gg, a serving of meat, and a serving of another protein food (such eans) or a second serving of meat. With these protein foods other items that would be in a mixed diet the intake will most y meet the Recommended Allowance. To compute the adequacy he protein in diets easily, Fig. 15 has been prepared showing the roximate fraction of the total day's need furnished by some monly used foods.

he menus in Table 9 are planned to provide an adequate intake of ein at three levels of cost based on local prices. We assume that the most part the same relative prices prevail elsewhere. Season supply, of course, alter the price differential.

the low cost meal nonfat milk solids, beans, peanut butter, and

Amount of Food (College Men 16–19 years)	Approximate Fraction	Amount of Food (College Women 16–19 years)
8 ounces beef 1¾ quarts milk		7½ ounces beef 1⅔ quarts milk
9 ounces salmon 7 ounces cheese		7 ounces salmon 5½ ounces cheese
8 tbsp. cottage cheese 6 tbsp. peanut butter		6 tbsp. cottage cheese 4½ tbsp. peanut butter
2 eggs ¼ cup kidney beans 6½ slices bread 5 potatoes		1½ eggs ⅔ cup kidney beans 4½ slices bread 3¾ potatoes

15. The amount of an individual food needed to provide a certain fraction ıe day's Recommended Allowance of protein for college men and women.

Table 9. Meeting the Daily Protein Need of an Adult at Three Cost Levels

Food	Protein gm	Food	Protein gm	Food	Protein gm
LOW COST MENU					
Tomato juice, ½ c.	1.2	Bean soup, ⅔ c.	7.2	Meat loaf, 3 oz	11.0
Oatmeal, ⅔ c.	3.6	Sandwich, peanut butter, 2 T. enriched	8.4	Msh. potatoes, ½ c.	3.0
Enriched or w.w. bread, 2 sl.	4.2	or w.w. bread, 2 sl.	4.2	Cabbage, ½ c.	0.7
Nonfat milk, solids, 1 c.	8.6	Carrot sticks, ½ c.	0.6	W.W. bread or enriched, 2 sl.	4.2
		Raw apple, 1 med.	0.4	Vanilla pdg., ½ c.	4.3
		Nonfat milk, solids, 1 c.	8.6		
Total	17.6		29.4		27.2
MODERATE COST MENU					
Frozen or. jc., ½ c.	1.0	Canned mushroom soup, ⅔ c.	5.4	Rump pot rst., 3 oz	18.0
Egg, 1	6.0	Sandwich, cheese, 1 oz	7.1	Msh. potatoes, ½ c.	2.0
Enriched or w.w. bread, 2 sl.	4.2	enriched or w.w. bread, 2 sl.	4.2	Gr. beans, ½ c.	0.9
Milk, 1 c.	8.5	Lettuce wedge, ⅕ hd.	0.5	Celery sticks, ½ c.	0.7
		Apple betty, ½ c.	2.0	Pan rolls, 2	6.8
		Milk, 1 c.	8.5	Apricots, 2	0.5
Total	19.7		27.7		28.9
HIGH COST MENU					
Fresh or. jc., ½ c.	1.0	French onion soup, ⅔ c.	0.0	Roast rib beef, 3 oz	20.0
Egg, 1	6.0	Sandwich, ham, 2 oz	10.0	Baked potato, 1	2.4
Bacon, 2 sl.	4.0	Bread, 2 sl., w.w.	4.2	Asparagus, ⅔ c.	2.4
Blueberry muffins, 1 ea.	3.2	Relish plate olives, pickles, celery, carrots	0.2	Chef's salad, ⅔ c.	1.0
Milk, 1 c.	8.5	Apple betty, ½ c.	2.0	Cloverleaf roll, 1	3.0
		Milk, 1 c.	8.5	Fresh pineapple, ⅔ c.	0.4
Total	22.7		24.9		29.2

From *Composition of Foods—Raw, Processed, Prepared*, U.S. Department of Agriculture, Agriculture Handbook 8, 1950.

a cheaper selection of meat provide the protein. Irrespective of cost, the protein of meat, fish, and poultry is of good quality. It is fortunate that the supplementary value of proteins makes it possible to combine cereals and legumes with dairy and meat products to provide a diet adequate in protein at comparatively low cost. The high cost menu includes a more expensive source of meat than the moderate and low cost meals, a rib roast as contrasted to a rump roast and meat loaf.

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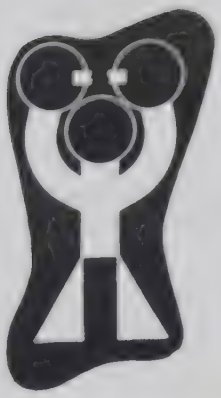
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CHAPTER 6





Digestion, absorption, and metabolism



When a hamburger or milk shake is eaten, nutrients that will ultimately be used to nourish the cells of the body are being ingested. Yet, before the nutrients contained in these foods finally reach the cells, the foods themselves must be digested and the nutrients absorbed. The *digestion* of the food involves the subdivision of the complex molecules into simple, soluble materials (the nutrients) which can pass through the lining of the digestive tract into the blood and lymph streams. After absorption, the nutrients enter into the chemical processes of the body cells. These processes involve the breaking down of foodstuffs to simpler forms, the synthesis or building up of cellular constituents, and the release of energy for use by the body—the sum of the processes is *metabolism*.

Digestion

The beginning of the study of digestion

As indicated in earlier chapters, the mystery of what happens to food in the body led philosophers of the prescientific era and the scientists who followed them to the study of respiration. The study of digestion also began in quest of an answer to that mystery. The first notable contribution was made by Rene de Reaumur (1683–1757), a French scientist who studied changes of the food in the

ach (2). He performed his experiments on his pet buzzard, a which swallowed its food in large pieces and later regurgitated estible portions. Reaumur took advantage of this unique opnity and trained his pet to swallow sponges. When the sponges brought up, they were soaked with gastric juice. He found the juice squeezed from the sponge would liquefy meat.

ne next important investigations were made by Lazzaro Spallanzani 9–1799) who studied the action of saliva on foodstuffs and verified mur's observations on gastric digestion. He performed a number aring experiments on himself. He was impelled to use himself subject because of his conviction that since certain observations igestion in animals had been made, he should try to do the same man. He wrote of his plans:

ntended to make these experiments on myself but I admit that those ving the use of tubes seemed to me to be rather dangerous, for I knew bodies held up in the stomach without being digested had led to dire equences and after a considerable time had been vomited up. . . . ever, the various contradictory facts that are current encouraged me y these experiments; I knew that very hard stones, like those of chermorellas, medlars, and plums were swallowed with impunity by chiland country people and they passed through the anus very easily out causing the slightest discomfort: in the midst of this struggle the ous events which I recorded induced me to overcome my reluctance

allanzani swallowed little linen bags containing food; he found is satisfaction that digestion takes place in the human stomach.

ost important were the contributions of William Beaumont (1785–), a physician stationed at a military post in the forest of North- Michigan. He took advantage of the unique opportunity of ying the processes of digestion in the victim of a gunshot wound ch left a permanent opening (fistula) into the stomach. His sub- Alexis St. Martin, was a trapper. During the first two years the accident, Beaumont tried to close the wound. Failing to do ne grasped the opportunity of making studies of gastric digestion. ook infinite patience and ingenuity to maintain the cooperation Alexis St. Martin through the years of study. His epoch-making rvations were of movements of the stomach during digestion of the normal appearance of the gastric mucosa.

hese studies were fundamental to the advances that followed in study of digestion in the nineteenth and twentieth centuries and to the present day knowledge.

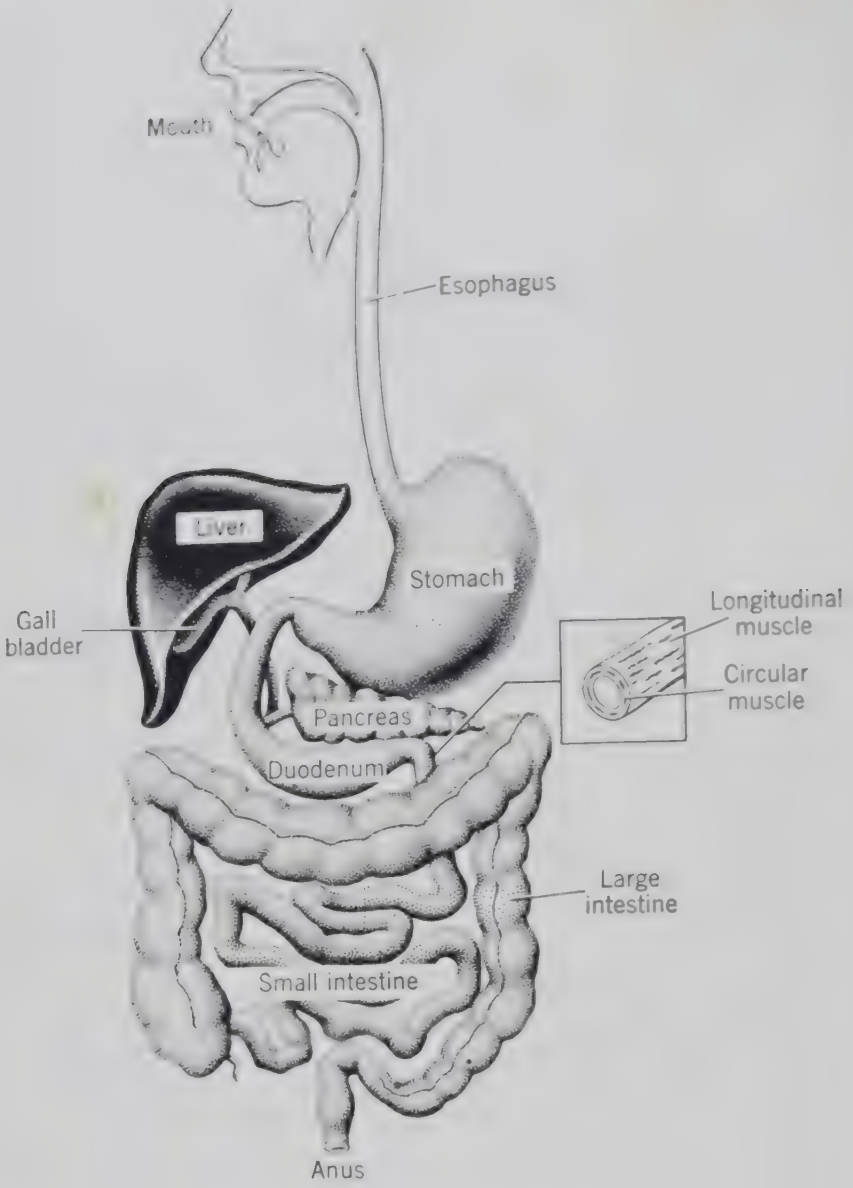


Fig. 16. The digestive tract.

The processes of digestion

Even though most of the food eaten is composed of complex molecules, there are certain factors in food like the simple carbohydrates, the minerals, and water that can be absorbed directly because of their elementary chemical structures. The digestion of the more complex food molecules, however, takes place in the gastrointestinal tract between the mouth and the end of the small intestine (Fig. 16). Digestion is brought about by both mechanical processes and chemical action.

nechanical phase of digestion

ne mechanical phase of digestion, which is responsible for the ag, subdividing, and moving of the food along the digestive tract, rought about by chewing in the mouth and by the muscular ity of the walls of the tract itself. These walls contain two s of muscular tissue: muscle fibers that run in a circular direction muscle fibers that run in a longitudinal direction (Fig. 16). en the circular fibers contract, the squeezing process results in the being mixed and subdivided into smaller pieces. The contrac- of the longitudinal fibers, on the other hand, causes the food to be pushed on through the tract. The coordinated movement hese two kinds of muscle fibers results in a wavelike motion all g the digestive canal called *peristalsis*.

he movements of the stomach are interfered with by nervousness anxiety. Eating when fatigued, agitated, or worried may give rise gastrointestinal disturbances. Hurried meals under tense condi- are not conducive to normal digestive movements.

chemical phase of digestion

he chemical phase of digestion, which is responsible for the nical breakdown of the food, is brought about by the action of oup of complex chemical substances called *enzymes*. An enzyme n interesting substance because it can become involved in a

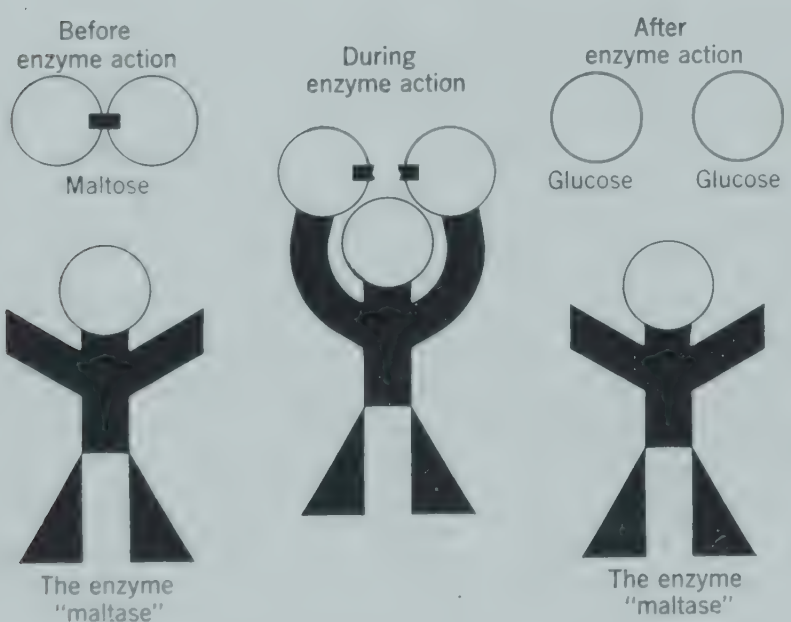


Fig. 17. A sketch showing the action of an enzyme.

chemical reaction without undergoing any change in itself. The sketch (Fig. 17), illustrates how the enzyme, maltase, aids in breaking down the disaccharide, maltose, to two molecules of the monosaccharide, glucose, without changing its own chemical structure. Although in this chapter, only the enzymes concerned with digestion are discussed, there are many others that are important in the body's overall function.

The digestive enzymes

The digestive enzymes are produced by the organs of the digestive tract. They aid in the breakdown of the complex carbohydrates to simple sugars, the fats or lipids to glycerol and fatty acids, and the proteins to amino acids. A distinctive feature of an enzyme is that it is specific; those that act on carbohydrates are not capable of acting

Table 10. The digestive enzymes

Source of the Enzyme Secretion	Site of Enzyme Reaction	Names of Enzymes and the Substances They Act Upon			
		Starches	Sugars	Fats	Proteins
Salivary glands	Mouth	Salivary amylase			
Stomach	Stomach			Gastric lipase	Castric protease
Pancreas	Small intestine	Pancreatic amylase		Pancreatic lipase	Pancreatic proteases
Wall of small intestine	Small intestine		Sucrase Maltase Lactase		Intestinal proteases

on fats or proteins and vice versa. Even though a naming system for the enzymes has been adopted, certain names which were chosen before this system was established are still in use, such as pepsin and trypsin. In the new system of enzyme nomenclature, the root of the enzyme name is derived from the substance that it acts upon (the substrate) plus the suffix "ase," the characteristic designation of an enzyme. Enzymes that subdivide a carbohydrate, a fat or lipid, and a protein are called *carbohydrases*, *lipases*, and *proteases*, respectively. For a specific carbohydrate such as starch, the root of the enzyme name is derived from the word "amylum" meaning starch, thus *amylase* is the root of this enzyme name. However, the root names of the disaccharide-splitting enzymes are derived from the

ars themselves, i.e. *sucrase*, *maltase*, and *lactase*. Because the steps digestion for one nutrient may occur in different parts of the estive tract, an adjective that describes the source of the enzymatic retion is used before the root word to complete the enzyme name able 10). For example the fat-splitting enzyme, which acts in the ll intestine, is secreted by the pancreas and is called pancreatic se.

estion in the mouth

ood enters the digestive tract through the mouth where it is wed, broken into small pieces, and mixed with saliva. The fluid reted by the salivary glands contains the first of the digestive en-nes, salivary amylase, which hydrolyzes starch or dextrin by split-g off molecules of maltose from the long carbohydrate chain (Fig. . Furthermore, the lubricating action of the saliva aids in the llowing of the food when it passes from the mouth to the stomach way of the *esophagus*.

estion in the stomach

When food enters the stomach, it remains temporarily in the upper tion of the organ, though most of the digestive action occurs in lower part of the stomach. Gastric juice, which contains hydro-oric acid, pepsinogen, pepsin, and gastric lipase, is secreted in the er part of the stomach and is mixed with the food by the churning on of the stomach walls.

Hydrochloric acid plays an important role in gastric digestion. It vates the protein-splitting enzyme, pepsin; creates the optimum lity in the stomach for the digestion of protein; and acts as a tericide preventing the entrance of bacteria into the lower diges- tract. In addition to these functions, hydrochloric acid also reases the solubility of calcium and iron resulting in the optimum orption of these essential nutrients in the small intestine.

The protein-splitting enzyme, pepsin, is secreted in its inactive m, pepsinogen, otherwise when the stomach is empty of food the yme would begin to digest the stomach wall. In this first step of tein digestion, the long chain of a protein is split into smaller units ed *polypeptides* by the enzymatic action of pepsin (Fig. 19). e polypeptides, which vary in size, may contain as few as three no acids linked together or as many as several hundred.

ecause gastric lipase is inactive at the normal acidity of the gastric tent, there is little fat digestion in the stomach. For this reason enzyme may be of little physiological importance to man. Only

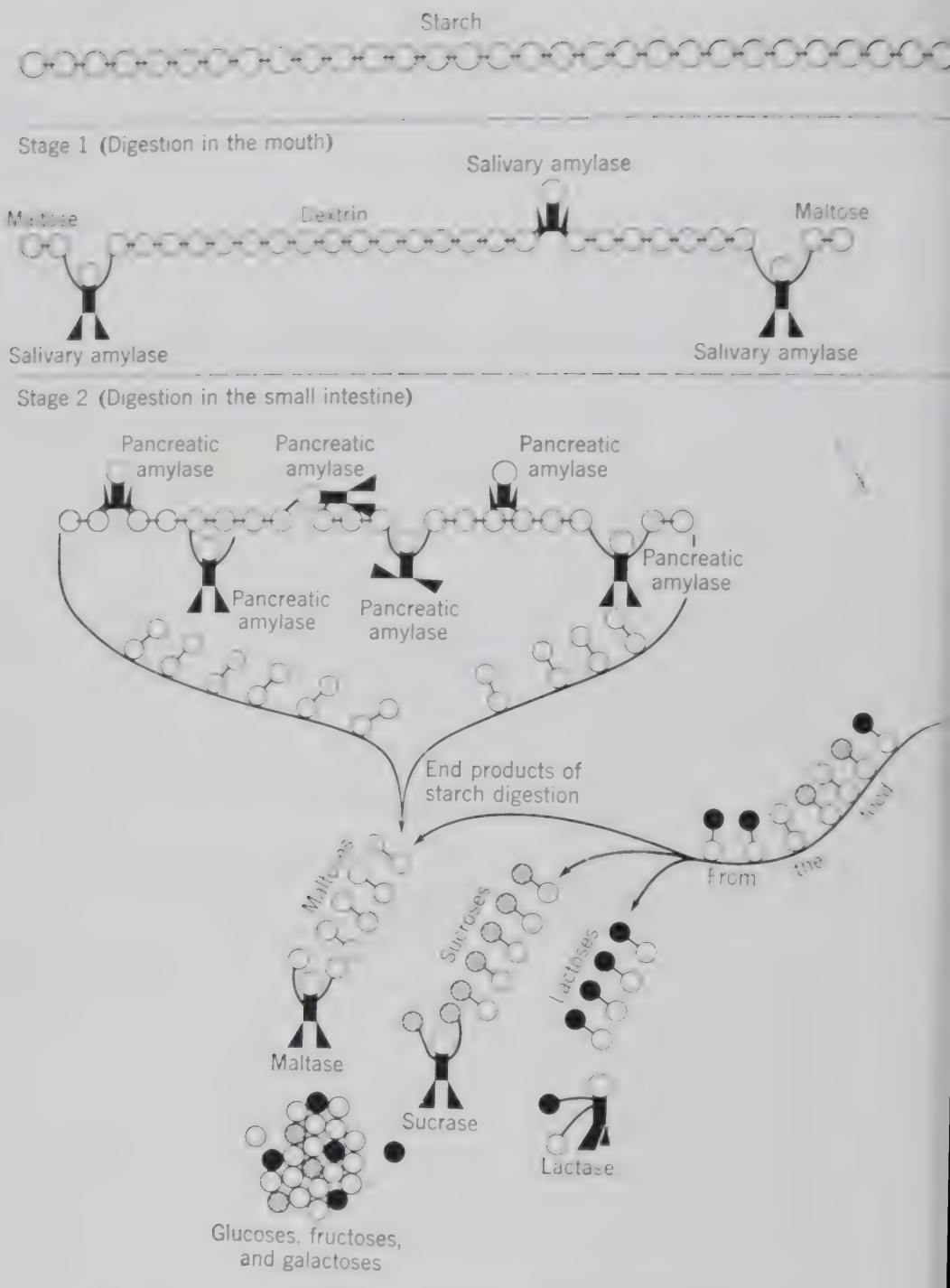


Fig. 18. A sketch showing starch and disaccharide digestion.

ats that are in a highly homogenized form as found in milk or olk can be digested in the stomach.

r a long time the clotting of milk in the human stomach has been buted to the action of the enzyme, *rennin*. Some authorities now ve, however, that rennin is not present in the stomach of the , but that it may be present in the infant gastric secretion and functions in the early period of life.

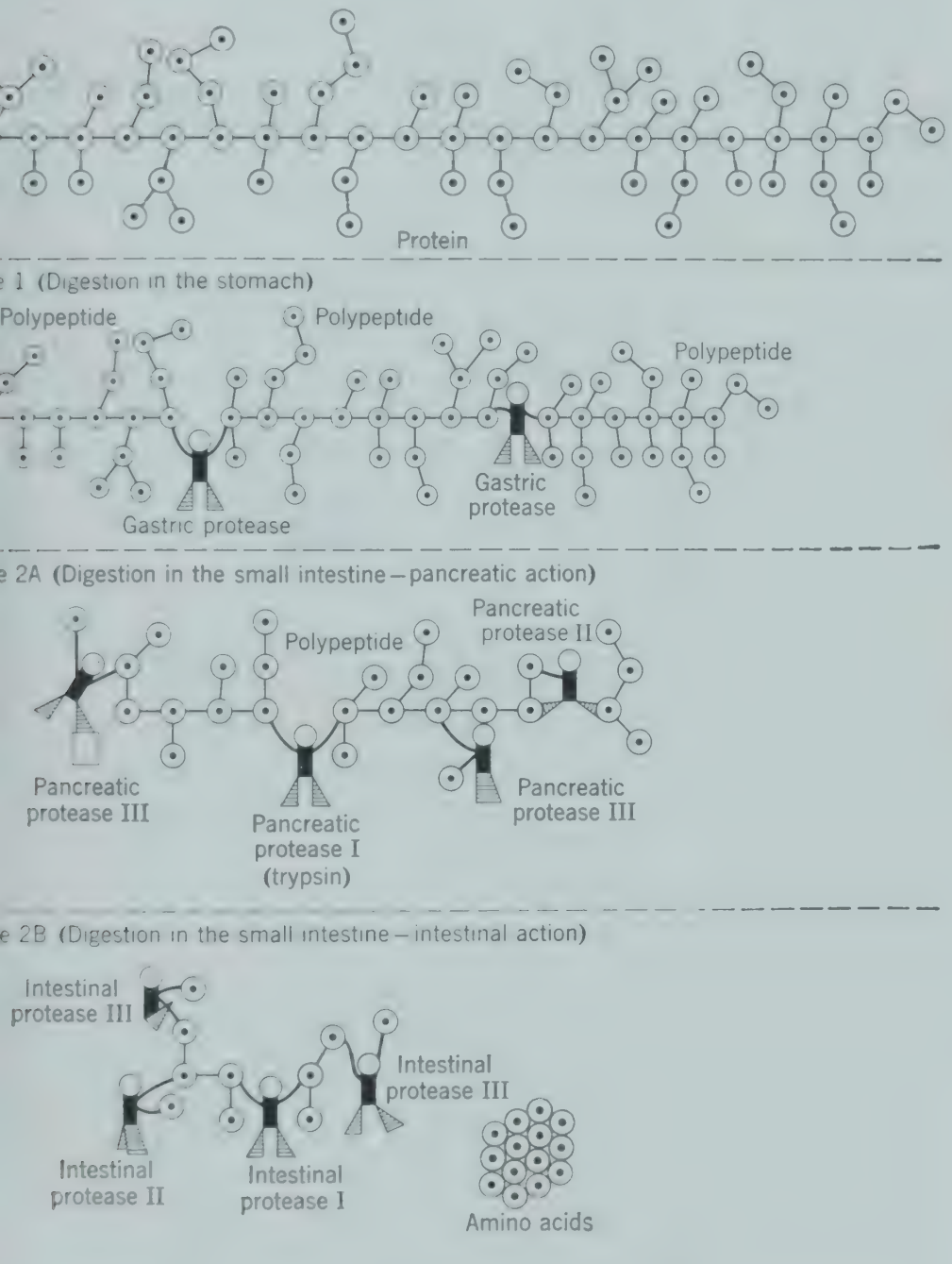


Fig. 19. A sketch showing protein digestion.

The length of time that food remains in the stomach differs w the composition of the diet and varies widely between individuals comparable food mixtures. An ordinary mixed meal leaves t stomach in three to four and one-half hours. Carbohydrate foo leave the stomach most rapidly, followed by protein, with fat foo remaining in the stomach for the longest length of time. The sens tion of hunger occurs more quickly after a meal relatively high carbohydrate than after a meal containing adequate protein and fat.

Digestion in the small intestine

After leaving the stomach, the highly liquefied food mass whic is referred to as *chyme* passes into the first section of the small inte tine, the *duodenum*. Into this area flow the intestinal juices, th pancreatic juices, and the bile. The secretions of the pancreas an the small intestine contain enzymes necessary for the complete dige tion of carbohydrates, fats, and proteins.

Carbohydrate digestion, which began in the mouth, is resumed the duodenum. Here, nature has provided a second amylase to co vert any remaining starch or dextrin to maltose, thus completing th conversion of starch to the disaccharide, maltose (Fig. 18). Pa creatic amylase appears to be more potent in this action than salivary amylase. Even uncooked or raw starch, which was not act upon by the amylase of the saliva, may be digested by the pancreat form of the enzyme. It should be noted, however, that raw starch are less digestible than cooked starches because of the nature of t starch granules. Raw potato starch is rather poorly digested and consumed in large quantities a significant amount of this particul starch may pass through the digestive tract without change. Oth carbohydrates, the disaccharides, which are found in the food inta or as end products of amylase action must also be changed to simp sugars before they can be absorbed by the body. The three carb hydrases in the intestinal secretion (sucrase, maltase, and lactase) co plete the hydrolysis of the carbohydrates to glucose, fructose, an galactose (Fig. 18).

Because there is little enzymatic action produced by gastric lipa the digestion of fats from the practical standpoint actually begins the small intestine. The two secretions which are involved in th fat-splitting process are the bile and the pancreatic lipase (Fig. 20 A fraction of the bile fluid, the bile salts, acts as emulsifying age In the process of emulsification the fats are broken up into sm globules which are more easily hydrolyzed by the pancreatic lipa Not all of the fat is digested to the glycerol and fatty acid stage b

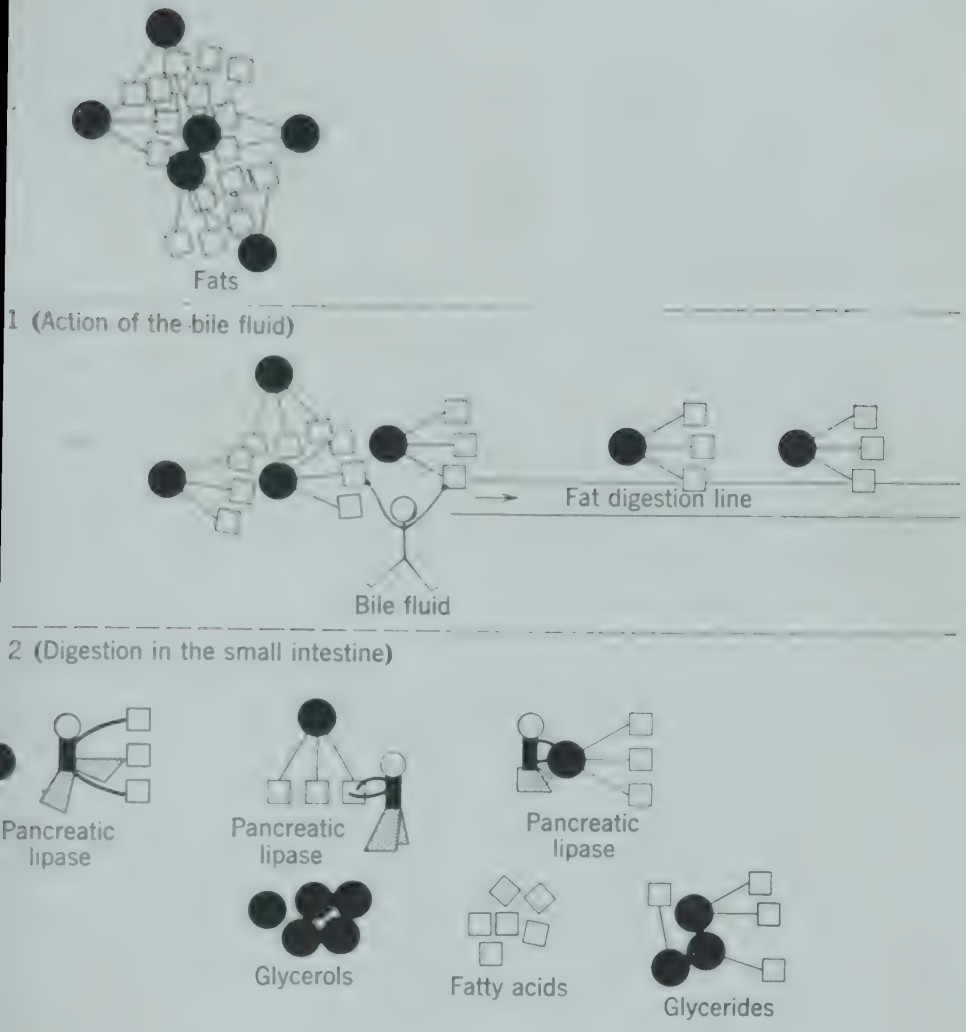


Fig. 20. A sketch showing fat digestion.

ase; some of it is hydrolyzed only to di- or monoglycerides, are compounds composed of glycerol and two or one fatty).

psin is one of the three protein-splitting enzymes contributed "digestive pool" by the pancreatic secretion. As in the case gastric protease (pepsin), trypsin is also secreted in its inac- orm, trypsinogen, which prevents digestion of the intestinal Trypsin and the other two pancreatic proteases attack the f the polypeptide chains and further subdivide them into poly- es of smaller units (Fig. 19). Finally, the complete breakdown polypeptides to amino acids is brought about by the action of additional protein enzymes, intestinal protease I, intestinal pro- II, and intestinal protease III, secreted in the intestinal juice 19).

The large intestine

The material entering the large intestine (colon) contains u
gested residues, some of the end-products of digestion that had
caped absorption, bile pigments and other waste materials, and wat
No digestive enzymes are secreted in the colon. Little change occ
except for the absorption of water.

Absorption

Before the body may use the soluble products formed during dige
tive action, the nutrients must be absorbed through the lining of th
digestive tract. Even though water and small amounts of simp
sugars pass through the mucosa of the stomach into the blood strea

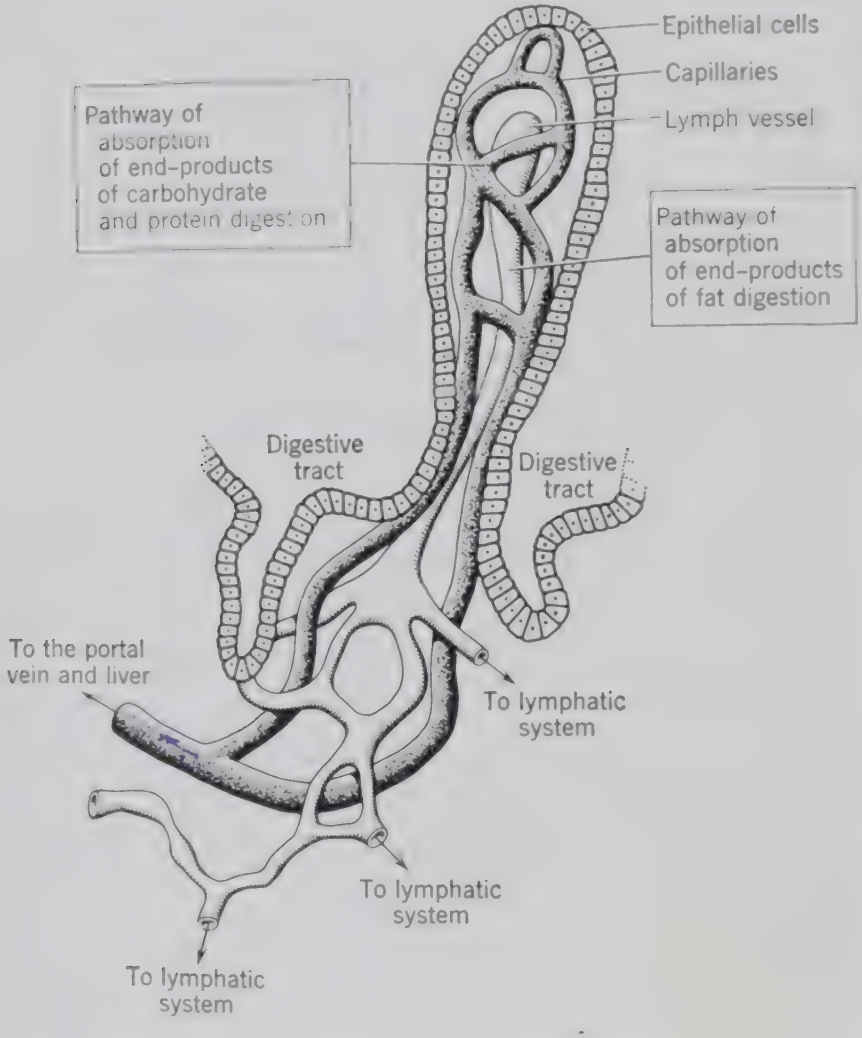


Fig. 21. A sketch of a villus, the absorptive organ of the small intestine.

of the absorption takes place in the small intestine. The absorp-
rea of this section of the digestive passageway is greatly in-
d by the *villi*, which are fingerlike projections in the lining of
nall intestine. Each villus contains a lymph vessel surrounded
network of capillaries (Fig. 21). The nutrients absorbed into
mph vessel pass into the lymphatic system, and those absorbed
e capillaries empty into the portal vein and are carried directly
liver. The lymph vessels are the "connecting passageways" in
ody, between the blood and tissues, by which food material and
n are brought to the individual cells.

ption of end-products of carbohydrate digestion

st of the simple sugars, the end-products of carbohydrate diges-
are absorbed directly into the capillaries and are carried by way
portal vein to the liver where those not needed for energy may
nverted to glycogen for storage. Small amounts of the mono-
arides may be absorbed by way of the lymphatic system. Car-
drates other than monosaccharides are not absorbed through the
nal wall.

ption of end-products of fat digestion

the present time, it is believed that the end-products of fat di-
n are absorbed through the intestinal wall in two ways: in the
of glycerol and fatty acids, and in the form of glycerides (Fig.
Moreover, after the glycerol and fatty acid molecules pass into
testinal wall, the two may recombine to form a fat molecule.
the glycerides and the reformed fat molecules, as well as any
rol and most of the fatty acids that may be present, pass into the
n vessels. They bypass the liver and later enter the blood
n. Then the end products are transported directly to the tissues
e they are either used for energy or stored as body fat.

ption of end-products of protein digestion

e amino acids formed during protein digestion are readily ab-
d from the intestinal tract into the capillaries and pass to the
by way of the portal vein. From here they are carried by the
to the tissues where they are used in protein metabolism as
d.

is now known, however, that protein derivatives larger than
acids may be absorbed into the blood stream. The etiology
od allergies suggests that small amounts of intact or partially
lyzed proteins from foods must be absorbed by the body. This

appears to be true because the allergy-produced reactions (asthma skin eruptions, etc.) are no longer present when the proteins causing the allergy are completely hydrolyzed to amino acids. Furthermore hay fever is known to be caused by certain proteins from pollen and other sources which enter the body through the respiratory tract.

Absorption of other nutrients

Minerals and vitamins are absorbed from the small intestine. Water can be absorbed from the stomach, the small, and also the large intestine.

Metabolism

Metabolism may be described as all the chemical changes that nutrients undergo from the time they are absorbed until they become part of the body or are excreted from the body. The two general phases of metabolism are referred to as *anabolism* and *catabolism*. The anabolism phase involves all the chemical reactions that the nutrients undergo for the construction or building up of body materials such as blood, enzymes, various tissues, hormones, glycogen and others, whereas catabolism involves those reactions in which various compounds of the tissues are broken down. *Energy metabolism* is the general term that has come to be used to describe all the changes, both chemical and physical, that the energy nutrients undergo in the release of energy for the body's use.

Carbohydrate metabolism

After the end-products of carbohydrate digestion, the monosaccharides, reach the liver, they are either used for energy or stored depending upon the body's immediate need. The monosaccharides other than glucose, however, are normally changed to glucose in the liver cells. Then, these glucose molecules are sent out to all parts of the body, via the blood stream, and pass from the blood stream into the tissues and cells by way of the fluids which surround the cells. The carbohydrate is oxidized in the cell to supply energy needed for the body processes.

The formation of glycogen. The formation of glycogen in either the liver or muscle cells has been sketched in Fig. 22, to represent a factory where the conversion and storage of glycogen occurs. The process whereby dietary monosaccharides (blood glucose) are converted to glycogen is called *glycogenesis*. The glycogen formed, often referred to as animal starch, is stored both in the liver and in the muscle. However, only limited amounts of this complex carbo-

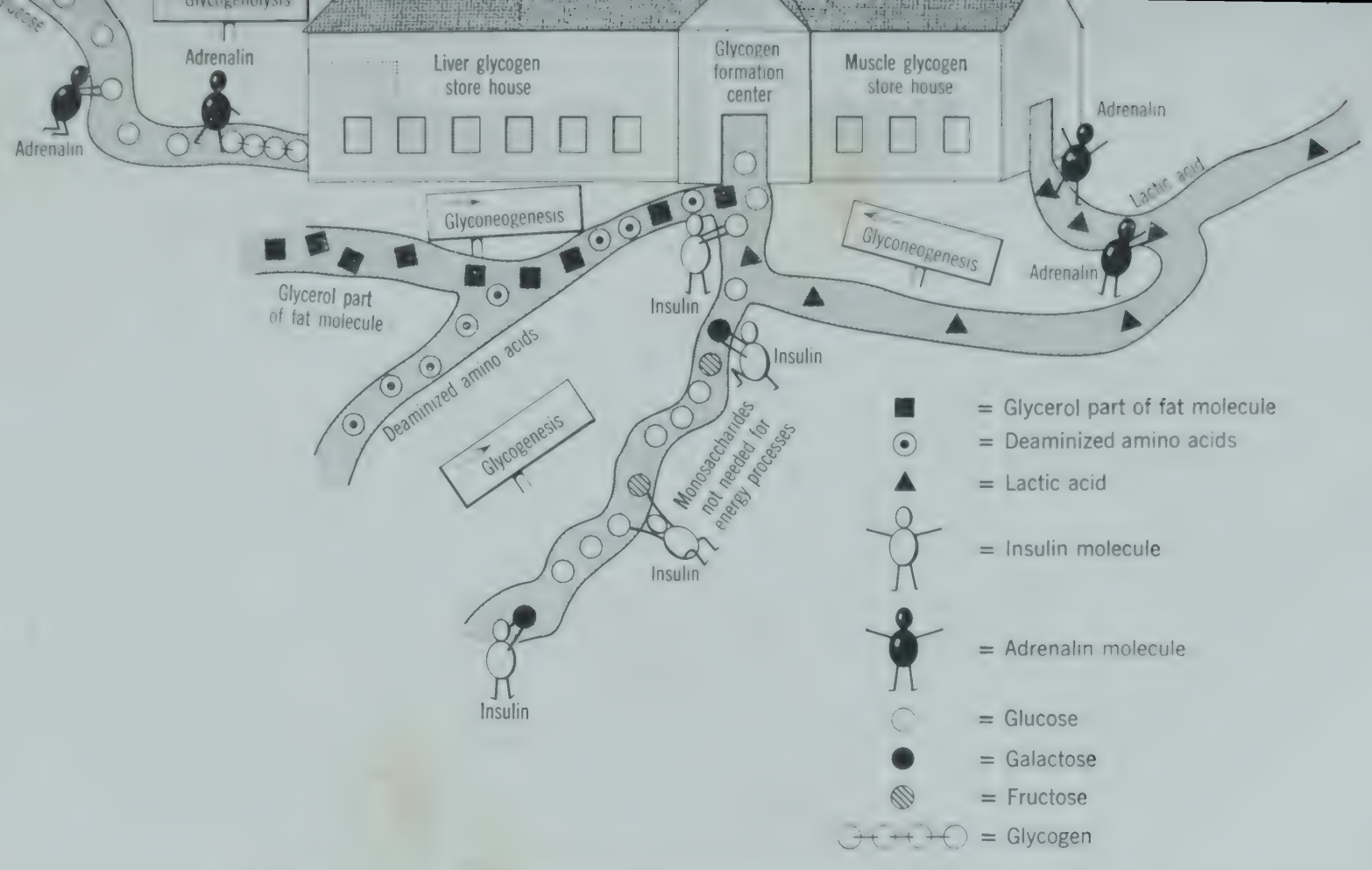


Fig. 22. A sketch showing the formation and breakdown of glycogen.

hydrate can be stored as compared to the storage capacity of the body for fat. It has been estimated that the liver may store up to 10 per cent of its weight in glycogen or about 100 gm. and the storage capacity of the muscle is only about 2 per cent of its weight.

Insulin plays an essential role in carbohydrate metabolism. This hormone, which is secreted by the Islets of Langerhans of the pancreas, aids not only in the oxidation of glucose in the body but also accelerates the conversion of blood glucose to glycogen (Fig. 22).

The breakdown of liver and muscle glycogen. The breakdown of both liver and muscle glycogen is shown in the factory sketch (Fig. 22). When extra energy is needed by the body, the liver glycogen is mobilized and changed to glucose by a process called *glycogenolysis*. Actually, this is the reverse of glycogenesis and occurs only in the liver cells. *Epinephrine*, commonly referred to as *adrenalin*, is the hormone produced by the adrenal glands which stimulates the breakdown of liver glycogen. After the glucose has been formed, it leaves the liver and passes to the tissues for immediate use.

Adrenalin also promotes the change of muscle glycogen but, in the muscle breakdown of glycogen, lactic acid instead of glucose is formed. However, part of the lactic acid produced can be reconverted to glycogen and stored in the liver (Fig. 22).

Glucose formation from non-carbohydrate sources. Although most of the glucose in the body arises from dietary carbohydrates, it may be formed in the liver from non-carbohydrate molecules by a process called *glyconeogenesis* (Fig. 22). The three sources of non-carbohydrate molecules, which may be precursors of liver glycogen and finally blood glucose, are lactic acid (formed on the breakdown of muscle glycogen), the glycerol part of the fat molecule, and *deaminized amino acids*. A deaminized amino acid is one in which the amino group (NH_2) has been removed.

Oxidation of glucose or glycogen for energy. The steps in the oxidation of glucose or glycogen for energy are pictured in Fig. 23 as the way of a highway system. Inasmuch as the oxidation process occurs in two parts, the highway in the sketch has been divided into the "metabolic roadway" and the "metabolic parkway."

The first stage in the oxidation process involves the breakdown of glycogen or glucose to pyruvic and lactic acids. This conversion is not a simple chemical change but occurs in many complex enzymatic reactions which are sketched in Fig. 23 as chemical steps along the "metabolic roadway." In addition to this, a derivative of the glycerol part of the fat molecule enters the oxidation cycle along the "metabolic roadway" (*1*).

second stage in the oxidation process involves the breakdown of
ic acid to carbon dioxide and water with the release of energy.
y is released when one molecule of pyruvic acid goes through
omplete cycle of the chemical changes known as the Kreb's
, and featured in Fig. 23 as the chemical steps along the "meta-
parkway." Deaminized amino acids and a derivative of the fatty
art of a fat also enter the metabolic pathway during this stage of
olism. One will notice in Fig. 23 that the parkway pictured in
etch does not always go in both directions. Actually, there are
n sections along the "metabolic parkway" that are just "one-
oads" where the chemical reactions of the oxidation proceed
n one direction and cannot be reversed. Along the "metabolic
ay," little "side-roads" enter the center of the system, and it
e that carbon dioxide, water, and energy leave the main high-

n though the exact mechanism found in the oxidation process
nplicated and involved, the sketch gives an idea of the series
own reactions which take place in this complex process.

version of carbohydrates to fats and amino acids. When carbo-
tes are ingested in quantities greater than the energy needs of
ody, the excess amount is converted to fat and stored in the
. This fact has been demonstrated by controlled experiments
both animals and man. From the sketch of the highway
n (Fig. 23) it can be seen how a fat may be formed from either
se or glycogen. The road from the "metabolic roadway" to
rol and from the "traffic circle, acetyl-coenzyme A" (which
ncerned with enzymatic processes involving 2-carbon com-
s) to fatty acids are both two-lane roads. Derivatives of either
gen or glucose may be diverted from the main roadway and
circle and travel along these side-roads to glycerol and fatty
These two substances then combine to form a fat which is
in the body tissues.

des being converted to fat, extra carbohydrates may also assist
formation of amino acids. It can be seen how it is possible for
o occur from the highway map (Fig. 23). For example, the
ic acid formed at the end of the "metabolic roadway" may be
xidized to release energy, (2) reconverted to glycogen in the
y way of lactic acid (Fig. 23), (3) used for the synthesis of a
r (4) synthesized into an amino acid. It is here that the syn-
of the amino acid, alanine, occurs. In addition to alanine, two
amino acids, glutamic acid and aspartic acid, may be formed
the "metabolic parkway."

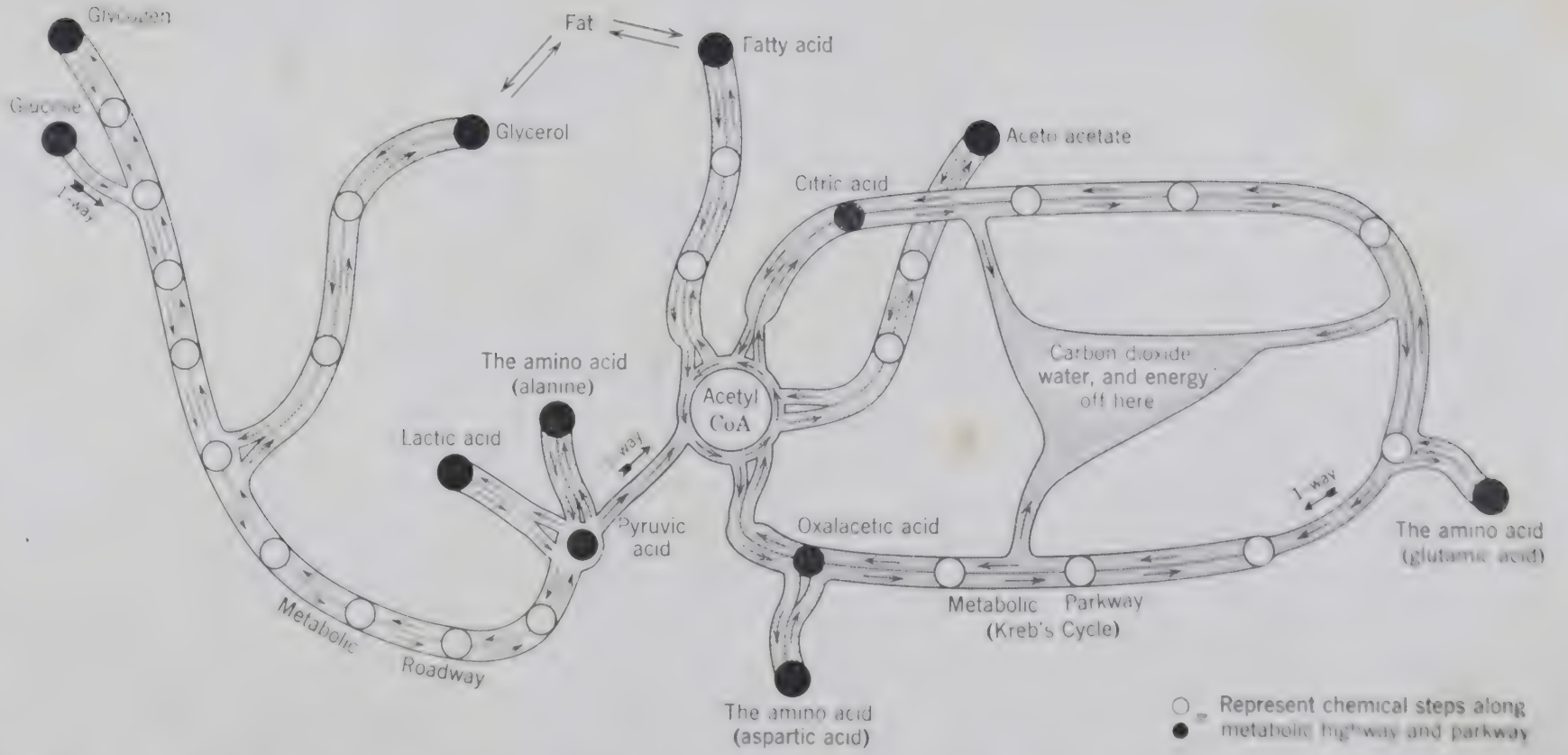


Fig. 23. A sketch showing the highway system which represents the pathway of oxidation for carbohydrates, fats, and proteins in the body. (Adapted from Best and Taylor (1955). *Physiological Basis of Medical Practice*, 6th ed. Williams and Wilkins, p. 58.)

abolism

the end-products of fat digestion are absorbed through the the intestinal tract, they pass into the lymph vessels on their the cells and tissues. Later they enter the blood stream, but doing so, some of the recombined fat molecules unite with les of phosphoric acid to form phospholipids, which aid in nsport of fatty acids in the body. The recombined fats, the olipids, the glycerides, the glycerol molecules, and the fatty ney go to all the body tissues where they are either oxidized rgy or stored as adipose or fatty tissue.

ation of fats. The components of a fat molecule, the glycerol n, and the fraction of fatty acids, are oxidized separately to energy for the body processes. Before oxidation can begin, re, any fat or glyceride must first be hydrolyzed to glycerol ty acids.

glycerol part of the fat molecule is first changed to a new and before it enters the "metabolic roadway" midway be- the point marked "glycogen" and that marked "pyruvic acid" 23. From here on, the oxidation of glycerol is the same as dation of either glucose or glycogen.

fatty acids, however, undergo several changes before they he "metabolic parkway" at the important traffic circle, acetyl- From this point they travel the same route as do the carbo- es and the glycerol fraction of the fat in order to release , carbon dioxide, and water for the body processes.

formation from carbohydrates and amino acids. Both carbo- es and amino acids may be used as sources of fats in the body. ormation of body fat from carbohydrates has already been ned under the section on carbohydrate metabolism. The con- of protein to body fat, however, involves the amino acids the metabolic pathway. As seen in Fig. 23, the amino acids the "metabolic parkway" are first deaminized and then may to the "acetyl-CoA traffic circle." From this point, they d along the road to fatty acids as well as along the "metabolic ay" to the junction where the road leads off to glycerol. The ol and fatty acid molecules then combine to form either a ide or a fat.

metabolism

amino acids, the end-products of protein digestion, are readily ed into the blood stream from the intestinal mucosa, pass to the

liver, and from there are carried to all the cells of the body. The
are three ways in which the amino acids are used by the body. Fi
some are synthesized to proteins and are used by the body to bu
new cells and to replace worn-out ones, and to form body regulato
i.e. hormones, enzymes, antibodies. Second, some of the amino ac
may exchange amino groups with other amino acids or even co
tribute amino groups to nonprotein materials to form new ami
acids. Finally, amino acids may undergo oxidation for energy pr
duction.

Formation of body protein. There is no specific theory at this tim
to explain just how body proteins are formed from the amino aci
available for that purpose. It is known, however, that a particu
tissue is selective in the kinds of amino acids used in its prote
synthesis. A discussion of factors related to protein formation in t
body is presented in Chapter 5.

Oxidation of amino acids. Before amino acids enter the metabo
pathway to be oxidized the amino groups must be removed. Th
reaction occurs in several steps and in many of the tissues of t
body but primarily in the liver and kidney. The amino group th
is removed forms ammonia before it is converted to *urea* in order
be excreted from the body. The urea, which is the final nitrogeno
product in the decomposition of proteins in the body, is then carri
to the kidneys where it is eliminated in the urine. The oxidation
the remainder of the amino acid, however, follows the pathway
carbohydrate metabolism (Fig. 23). After the amino acids have be
oxidized for energy, the end-products are excreted from the bo
as carbon dioxide, water, urea, and other nitrogenous constituen
The kidneys are the pathway of excretion of the nitrogenous en
products of protein metabolism.

Conversion of amino acids to carbohydrate and fat. As has be
noted in the discussion of carbohydrate and fat metabolism, amin
acids may be converted to either carbohydrate or fat in the norm
processes of metabolism (Fig. 23).

REFERENCES

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Practice.* 6th ed. Williams and Wilkins Co., Baltimore.
2. Fulton, J. F. (1930). *Selected Readings in the History of Physio
Charles C Thomas, Baltimore.

APTER 7

The need for energy

energy nutrients (including protein), their digestion, ab-
n, and metabolism have been discussed. The next step in the
story is to present the factors which comprise the total
need as well as the caloric requirement of man.

History of Energy Metabolism

oisier, who is called the "Father of Nutrition," laid the founda-
or the basic principles of energy metabolism in the eighteenth
y through his discoveries of the importance of oxygen gas
process of combustion. The period of the development of the
ts of energy metabolism, however, extended throughout the
nth century with the work of many German scientists in-
g von Liebig and Rubner. Yet, the instruments used to measure
ergy expenditures of men and animals, as well as the potential
value of food products were only perfected in this century
n including Atwater, Armsby, and others. Since their efforts,
l, McCollum, Benedict, Sherman, DuBois, Mitchell, Maynard,
and other scientists have advanced the knowledge of potential
in foods and energy metabolism by obtaining quantitative data
n.

ntion was attracted away from work in the field of energy
olism when the first vitamins were discovered, shortly before
st World War. During the period of the Second World War,
er, when this country began to help feed the war-distressed

nations of the world as well as its own armies in the field, it bec
apparent that the available information on the energy composi
of food substances and the energy needs of man was inadequa
In contrast to this, an increasing awareness of the problems of ov
weight and obesity (caloric overnutrition) further stimulated the
terest and focused attention on the need for new energy research.
a consequence, there has been a broader study in this area of nutrit
There has been a reawakening of interest in energy metabolism du
ing the past decade.

Factors Which Determine the Total Energy Need

The four factors that determine the total energy need of an i
dividual are the basal metabolism, the physical activity, the main
nance of body temperature, and the specific dynamic effect of foo
The basal metabolism, which usually represents the largest fraction
the total energy expenditure, is the minimum amount of energ
needed to carry on the vital life processes of the body when awak
Energy for the performance of all types of physical activity ran
next to basal metabolism in amount of energy expended. The mai
tenance of the body temperature at its normal level and the ext
energy required to metabolize food (with a resulting increase in he
production, small as it may be, is known as the specific dynam
effect) are the remaining factors that are a part of the total energy r
quirement.

The Energy Need for Basal Metabolism

The *basal metabolism*, which may be defined as the amount of he
given off by an individual during physical, digestive, and em
tional rest, represents the amount of energy needed to carry
the vital life processes of the body (the activity of the hea
kidney, and other organs as well as the metabolic processes with
the cells). It excludes the energy needed for physical activit
the maintenance of body temperatures, and the specific dynam
effect of food.

The basal metabolism determination, which has a definite value
medicine, is used in many hospitals and clinics as a tool in diagnosi
certain disorders and diseases. From the measurement of the bas
metabolism, the conditions of *hypothyroidism* (an undersecretion
the thyroid gland) and *hyperthyroidism* (an oversecretion of th
gland) are recognized.

s of determining basal metabolism

neasurement of the basal metabolism of an individual may be
y indirect or direct calorimetry. Indirect calorimetry, the
re universally used, involves the determination of either the
of oxygen consumed and or the amount of carbon dioxide
d, which indirectly measures the amount of heat produced by
n in the cells of the body. A unit measure of oxygen is
nt to a given number of Calories when certain food and food
s are oxidized. It is assumed that under the conditions of the
etabolism determination that the individual is oxidizing a
iet.

machine used most widely to measure the basal metabolism is
nedict-Roth apparatus (Fig. 24), which involves the measure-
f the amount of oxygen used by an individual. The short
equired for a measurement as well as its operating simplicity



Benedict-Roth portable respiration apparatus for the determination of
etabolism. (Courtesy of Swift, Institute of Animal Nutrition. The
vania State University.)



Fig 25. Tissot respiration apparatus for the determination of basal metabolis (Courtesy of Swift, Institute of Animal Nutrition. The Pennsylvania State Un versity.)

have made it a most satisfactory instrument for medical diagnosi The Tissot apparatus (Fig. 25), which involves the collection an analysis of expired air of an individual, has been found to be a d sirable instrument for determining the basal metabolism in exper mental studies. This method is expensive both in operating time an cost of equipment but because a greater accuracy in the basal measur ment is possible, it is a valuable tool in energy research. Dire calorimetry, which is used most frequently in the study of energ need during exercise, is discussed later in this chapter.

Conditions under which the basal metabolism should be measured

There are certain conditions under which the basal metabolism an individual should be measured. First, the test should be made

ours after the last intake of food. To eliminate any effect of
n the heat production, the morning hours are generally used
measurement. Second, the subject should be awake and lying
in a room of comfortable temperature. During sleep the basal
lism of an individual is approximately 10 per cent lower than
ne is awake. Any activity on the part of the subject or need
duce heat to maintain the body temperature will increase the
lic processes and result in an extra energy expenditure beyond
sal metabolism. Third, the subject should be relaxed because
sness or tension may cause an increase in the heat production.

to compute the basal metabolism

mple procedure for approximating the basal metabolism under
conditions is the "rule of thumb," 1 Cal. per kilogram per

sal metabolism = 1 Cal. × body weight in kilograms × 24 hr
Calories/24 hr)

kilograms of body weight are found by dividing the weight in
s by the factor 2.2. The calculation for the energy needed for
sal metabolism of a college man weighing 176 lb. would then be:

$$\text{Basal metabolism} = 1 \times \frac{176}{2.2} \times 24$$

$$= 1920 \text{ Cal.}$$

a more accurate estimation of the basal metabolism, laboratory
ds previously described are used.

s which may affect the basal metabolism

factors which may affect the basal metabolism are body size,
f body composition, age, climate, status of health (fever and
rition, or semistarvation), secretion of the ductless glands, as
s pregnancy, lactation, and growth. Although it was once
d that racial background had an effect on the basal heat
tion, recent studies involving the Eskimo, the New Orleans and
Indian Negro, and the Egyptian have shown the rates to be
the normal expected limits.

y size. The concept that basal metabolism is proportional to
area has been accepted by most students of nutrition. The
metabolism of individuals of the same height and age or people
same weight and age may differ or be influenced by the
on in the body form of the individuals. These differences can

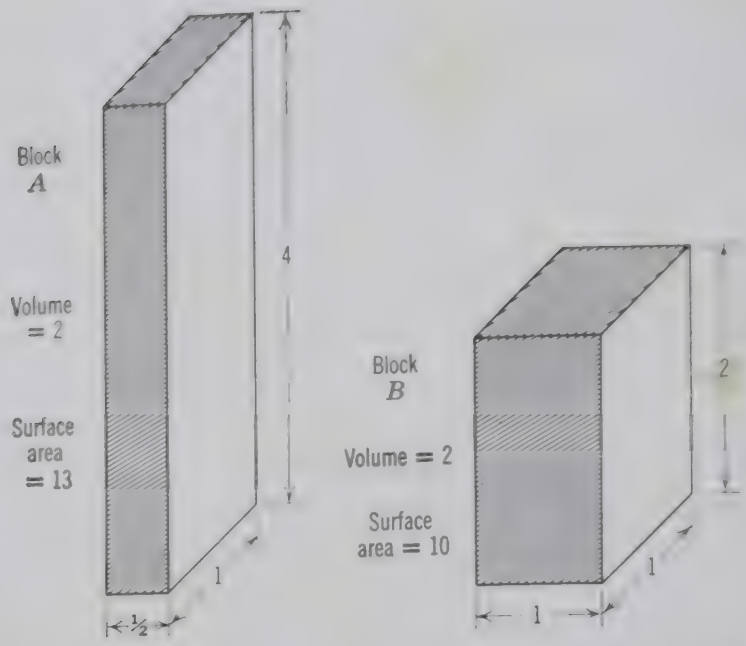


Fig. 26. Block *A* and *B* represent two men of the same age and body weight (volume = 2). Yet, the surface area of Block *A* (the tall, thin man) is 30 percent greater than that of Block *B* (the short, stout man).

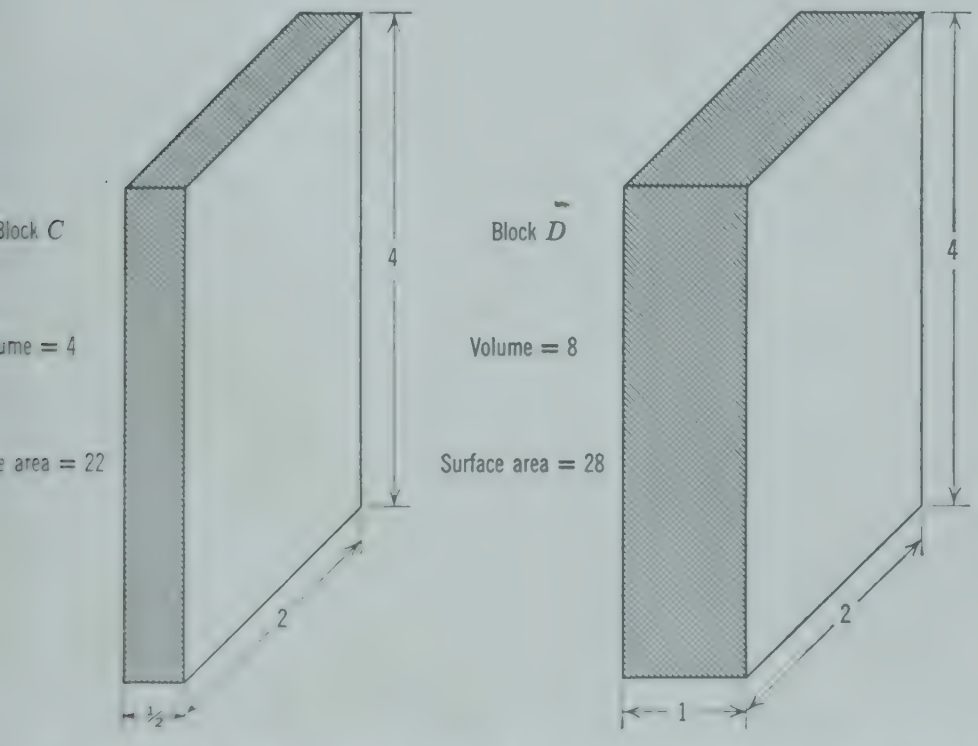
be explained by borrowing an idea from Best and Taylor (*1*) who illustrated the principles by using pieces of wood to represent the area of body surface. In the first example (Fig. 26) Block *A* and Block *B* represent two men of the same age and body weight but are different in shape, one being tall and the other short. Even though Block *A* and *B* are identical in volume and weight, the surface area of Block *A* is about one-third greater than that of Block *B*. Thus the tall man will have a higher basal metabolism per unit of body weight than the shorter man of the same weight. In the second example (Fig. 27) where Block *C* represents the thin man and Block *D* represents the stout man, the two men are of the same height and age but the thin man weighs one-half as much as the stout man. Here, the surface area of the stout block is only about one and one-fourth times greater than the thin block, not twice as great. These examples serve to show the important relationship that the body size and shape have to the actual basal heat production of an individual.

Types of body composition. The kinds of tissue that make up the body have a direct influence on the basal metabolism. In muscle tissue, for example, where oxidative processes are constantly taking place, more energy is expended than in fatty tissue. It has been estimated that an athletic-type man with well-developed muscular tissue

ve a basal metabolism about 6 per cent higher than a nonathlete
nparable body surface. Men have a 5 per cent higher heat pro-
n than do women of comparable body size and age, the higher
however, is not a sex difference, per se, but is attributed at least
to the smaller amount of fatty tissue found in men as compared
men.

Age is still another factor which affects the basal heat pro-
n of an individual. The caloric requirement, which is based
a of body surface, reaches its highest point at about 18 months
. Then there is a slight decrease in the caloric need from this
ntil the period of adolescence when another peak occurs. After
mpletion of growth, however, there is a gradual decline in the
heat production which extends from about age 20 throughout
It has been estimated that the basal metabolism of a man at 75
is about 20 per cent lower than that of a man at 20 years.

mate. Living in a cold climate does not appear to affect the
l basal metabolism of an individual to any great extent. The
studies done on white men and Eskimos (7) in Alaska show
eration in the basal heat production due to living in this cold



. Blocks *C* and *D* represent 2 men of the same age and height. Block *D*
e = 8) weighs twice as much as Block *C* (volume = 4), yet the surface
Block *D* is only $1^1/_4$ times greater than Block *C*, not twice as great.

part of the world. The effect of a hot climate on the basal metabolism has not as yet been satisfactorily investigated. In some of the earlier studies where lower basal metabolism values were found among people living in the tropics, it is difficult to conclude whether the differences reported were real or due to the use of trained subjects. Recent reports, however, confirm the earlier indications that people living in the tropics have "lower" metabolic rates, based on body weight, than do those living in the areas of the temperate zones (3).

Status of health. During periods of fever as well as malnutrition or semistarvation, the basal metabolism of an individual will be affected.

Illnesses involving an elevation of body temperature may markedly increase the basal heat production. For each degree rise in temperature above 98.6° F, the basal rate is increased about 7 per cent. For example, with a body temperature of 103.6° F, which is 5 degrees above normal, the basal metabolism will be increased 35 per cent.

Malnutrition will lower the basal metabolism, depending upon the degree of undernutrition. It has been observed that undernourished children, whose diets were inadequate in Calories, had lower basal metabolic rates per unit of body weight than did adequately fed children of the same age (6).

The classic studies by Keys and co-workers at the University of Minnesota (4) have shown the effect of semistarvation on the basal metabolic rate. Thirty-six healthy young men were the subjects for this 14-month experiment. The plan of the study included a 3-month control period followed by a 6-month semistarvation period and ending with 3 months of restricted rehabilitation and 2 months of unrestricted rehabilitation. The number of Calories ingested daily during these periods were approximately 3492, 1570, between 1931 and 2944, and then an unrestricted amount, respectively. Although the restricted caloric pattern of the diet for the semistarvation period resulted in a loss of about one-fourth the total body weight of the subjects, the basal consumption of oxygen was decreased only as much as 10 per cent below the prestarvation values. However, the transfer to an energy intake of 3200 Cal. or above per day during the unrestricted rehabilitation period resulted in a gradual restoration of the basal metabolism to the normal level.

Secretion of the ductless glands. The secretion of the thyroid gland has more influence on the regulation of the metabolic rate than do the secretions of any of the other ductless glands. When the thyroid oversecretes (hyperthyroidism) the basal metabolic rate increases; when it undersecretes (hypothyroidism) the basal metabolic rate is decreased. Increases in the basal metabolism from 75 to 100 per cent

een found in cases of *exophthalmic goiter* (hyperthyroidism) s in cases of *myxedema* (hypothyroidism), the metabolic rate e lowered as much as 40 per cent. Adrenalin, secretion of the l glands, causes a temporary rise in heat production. Certain ns of the pituitary secretion, the thyrotropic and also the tropic, exert an influence by stimulating the thyroid and adrenal to function. The secretions of other endocrine glands, how- ave a less marked effect, if any, on the basal heat production.

nancy, lactation, and growth. The increase in total active tis- ring pregnancy and growth result in an increase in the basal olic rate. Comparisons of the metabolic rates of pregnant n just before delivery showed increases of 15 to 23 per cent the pre-pregnant rates (5). The additional active tissue is ac- ed for by the developing fetus and enlargement of certain al tissues. An insufficient number of nursing mothers have studied under controlled conditions to state precisely the influ- of lactation on basal heat production. Indications are that lac- does not cause an increase.

ods of rapid growth are associated with an increase in the basal olism. The period of most rapid growth in childhood is in in- a baby during the first 5 or 6 months of life will double his weight, and triple it by the end of 12 months. At the end of st year of life or the early part of the second, the basal rate per meter of body surface is the highest in the lifetime of an indi- . At adolescence, when the growth rate again speeds up mark- he basal metabolic rate increases also.

The Energy Need for Physical Activity

kind of physical activity increases the energy expenditure the basal caloric need. The amount of energy needed for al work by the moderately active man or woman usually com- the second largest caloric expenditure, next after the expendi- or basal metabolism. This, however, would not be true for a active individual, such as a football player or a lumberjack; his expenditure for physical activity would rank ahead of that for metabolism.

nergy cost of physical activities

energy cost of physical activity is directly related to the nt of work done as well as to the body size. For example, it sixteen times as many Calories for a person to row a boat in a

Table 11. The Energy Cost of Activities Exclusive of Basal Metabolism and Influence of Food

Activity	Cal./kg/hr	Activity	Cal./kg/hr
Bicycling (century run)	7.6	Piano playing (Liszt's "Tarantella")	2.[illegible]
Bicycling (moderate speed)	2.5	Reading aloud	[illegible]
Bookbinding	0.8	Rowing in race	16.[illegible]
Boxing	11.4	Running	[illegible]
Carpentry (heavy)	2.3	Sawing wood	[illegible]
Cello playing	1.3	Sawing, hand	[illegible]
Crocheting	0.4	Sewing, foot driven machine	[illegible]
Dancing, foxtrot	3.8	Sewing, motor driven machine	[illegible]
Dancing, waltz	3.0	Shoemaking	[illegible]
Dishwashing	1.0	Singing in loud voice	[illegible]
Dressing and undressing	0.7	Sitting quietly	[illegible]
Driving automobile	0.9	Skating	[illegible]
Eating	0.4	Standing at attention	[illegible]
Fencing	7.3	Standing relaxed	[illegible]
Horseback riding, walk	1.4	Stone masonry	[illegible]
Horseback riding, trot	4.3	Sweeping with broom, bare floor	[illegible]
Horseback riding, gallop	6.7	Sweeping with carpet sweeper	[illegible]
Ironing (5 lb iron)	1.0	Sweeping with vacuum sweeper	[illegible]
Knitting sweater	0.7	Swimming (2 mph)	[illegible]
Laundry, light	1.3	Tailoring	[illegible]
Lying still, awake	0.1	Typewriting rapidly	[illegible]
Organ playing (30% to 40% of energy hand work)	1.5	Violin playing	[illegible]
Painting furniture	1.5	Walking (3 mph)	[illegible]
Paring potatoes	0.6	Walking rapidly (4 mph)	[illegible]
Playing ping pong	4.4	Walking at high speed (5.3 mph)	[illegible]
Piano playing (Mendelssohn's Songs)	0.8	Walking down stairs	[illegible]*
Piano playing (Beethoven's "Appasionata")	1.4	Walking up stairs	[illegible]†
		Washing floors	[illegible]
		Writing	[illegible]

Courtesy C. M. Taylor and Grace MacLeod, *Rose's Laboratory Handbook for Dietetics*, 5th ed., The Macmillan Company, New York, p. 18, 1949.

* Allow 0.012 Cal. per kg for an ordinary staircase with 15 steps, without regard to time.

† Allow 0.036 Cal. per kg for an ordinary staircase with 15 steps without regard to time.

s for the same person to wash dishes for the same period of time. l factors account for the difference. In the first place, many muscles are involved in rowing a boat than in washing dishes econd, the force exerted in handling a dish cloth is much less managing the oars of a boat. In addition to the type of work rmed, the body size of the person who does the work is also a . For example, it would take more Calories for a 176 lb (80 ollege man than for a 154 lb (70 kg) man to row a boat under me conditions.

e energy expenditures in different kinds of physical activities been compiled and are listed in terms of Calories per hour per am of body weight in Table 11.

ds of determining the energy needs for physical activity

e of the early ways devised to measure the energy used for a ular activity was by the Douglas method, an indirect method.



. The respiration gas-meter being used to measure the energy expenditure lege men while bowling. (Courtesy of Swift, Institute of Animal Nutri- he Pennsylvania State University.)

The expired air of the individual performing the activity is collected in a large bag and analyzed for carbon dioxide and oxygen content. Although an accurate method, its usefulness is limited because of the cumbersomeness of the collecting bag.

Recently a new type of apparatus called the *respiration gas meter* was designed and constructed at the Max-Planck Institute in Germany (Fig. 28). It consists of a light-weight box, containing a meter for recording the volume of the expired air, which straps on the back. The machine samples the expired air, portions of which are collected in a small bag attached to the meter. This eliminates the cumbersomeness of the Douglas method and increases the span of time for activity measurements. After the expired air collected during the activity performance test has been analyzed for carbon dioxide and oxygen, the caloric expenditure can be calculated. The respiration



Fig. 29. The Armsby Calorimeter now in use at The Pennsylvania State University. (Courtesy of Swift, Institute of Animal Nutrition, The Pennsylvania State University.)

ter can be used to measure the energy expenditure of an indi-
ither at rest or at work.

y indirect calorimetry methods are used to study the energy
man's physical expenditures. Yet, many of the early values
cost of physical activities were obtained by the use of direct
etry methods which involve the use of respiration chambers.
chambers, which were used by laboratories in Germany and
country, ranged in size from small ones that would accommo-
nly a man either in a standing or reclining position to those
ould house large farm animals. The Armsby Calorimeter (Fig.
hich is the largest respiration calorimeter ever constructed, is
use on the campus of The Pennsylvania State University. In
years this calorimeter has been used solely to study human
problems.

respiration calorimeter, as the name indicates, combines the
and indirect methods of energy determination. The complex
tus includes an airtight, well insulated chamber in which the
mental subject resides during a test period. The heat evolved
he occupant is absorbed by water that circulates in metal coils
l near the ceiling of the chamber. The amount of heat given
computed from the rise in temperature of the water during its
e through the chamber and the amount of water that flows
gh the coils during the period of observation. Direct calor-
also requires a knowledge of the amount of water that evap-
from the skin and lungs. This is determined by a comparison
water contents of the air entering and leaving the chamber.

indirect method of determining energy expenditure involves
alysis of the air entering and leaving the chamber for content
gen and carbon dioxide.

e Energy Need for Maintenance of Body Temperature

body maintains its normal temperature at about 98.6° F or
by both chemical and physical means. The chemical regula-
nvolves the production of heat within the cells from the metab-
of the energy nutrients whereas the physical regulation involves
ss or conservation of this heat in order to maintain a normal
al balance.

tion of body temperature

point at which the body must deliberately produce extra heat to
in a normal body temperature is referred to as the *critical tem-*

perature, which is about 73° F or 23° C in man. It has been report however, that shivering begins when the skin temperature reach 66° F or 19° C (8). Between the critical temperature and the po of shivering, there is a gradual increase in the heat production wh may be as high as 36 per cent. Shivering is an involuntary contra tion of the skeletal muscles to produce heat for the maintenance body temperature.

The condition of the body itself helps in the regulation of the bo temperature. A thin person with poorly developed layers of su cutaneous fat will have less insulation against heat loss in cold weath than a person of average weight. In contrast, a fat person with we defined layers of fat will suffer from the heat in warm weather b cause he is so well insulated.

Ways heat is lost from the body

Heat is lost from the body in a variety of ways. Most of the bo heat (about 95 per cent) is lost by means of *radiation*, *conductio* and by the *evaporation* of water from the skin and lungs. In t process of radiation, the heat actually radiates from the body to t outside air when the environmental temperature is below that of t body. In the process of conduction, heat is passed on by the body coming in contact with another object. For example, when a pers holds an ice cube in his hand, heat from the hand passes on to t cube and melts the ice. In man conduction plays a minor role in he loss. Evaporation of moisture from the skin and vaporization water from the lungs accounts for approximately 20 per cent of t heat loss. In addition to the three major avenues of heat loss the are other minor ones: body heat is used to warm the inspired air a the food or liquid intake to body temperature; and some heat is l through urine and feces—estimated to be as little as 2 per cent of t body's heat.

The environmental temperature affects the rate of heat loss, a the manner of heat disposal is affected by the humidity of the a When the environmental temperature is lower than that of the bod most of the heat will be lost by radiation and conduction. Howev when the temperature of the environment is equal to or above bo temperature, all the heat must be eliminated by perspiration and eva oration of water from the lungs, because heat will neither radiate n be conducted from a body of equal or lower temperature than environment. Furthermore, dry air will favor a more rapid rate evaporation of water from the body than will moist or humid a It is for this reason that during the summer months a 100° F temper

ported from a low humidity area like Arizona will not cause discomfort to an individual as an 85° F temperature reported humid area along the seacoast.

at man controls his environmental temperature

ectly, man controls his environmental temperature by wearing g, living in houses, and taking advantage of devices which id cool. An open-weave, light-weight fabric such as linen the radiation of heat from the body, while the closely woven of woolen cloth insulate the body against the loss of heat. in warm and cold climates are insulated to resist the passage in or out.)

The Energy Need for the Specific Dynamic Effect

increased heat production brought about by the ingestion of self is referred to as the *specific dynamic effect.*) It is possible lain the relationship of the specific dynamic effect to food y comparing it to the system of tax withholding now in effect country. For example, if a man earns $400.00 per month, his ome" pay is not $400.00 but only $360.00 after taxes. The salary in this example represents the caloric value of a meal the $40.00 tax represents the heat increment of the specific ic effect.

ne past, the specific dynamic effect of food on the total metab- has been greatly overrated. Early workers observed a dra- ncrease in heat production by feeding test meals of individual ns of each of the three energy nutrients (carbohydrate, fat, or) as the sole nutrient in the diet. They assumed, moreover, e dynamic effect of a mixed diet would be the sum of the in- brought about by each of its individual components and failed y the actual heat production on diets which contained portions hree of the energy nutrients.

energy expenditure for the specific dynamic effect has been in human experiments to be a small part of the total expendi- Experiments have been conducted on college men to study namic effects of long-time intakes of both high (about 122 gm and low (about 34 gm daily) protein diets of equal Caloric (9). These mixed diets were composed of commonly used and the two levels of protein used represent the two extremes tein intake which might be encountered within a population The Armsby Calorimeter (Fig. 29) was used to measure the

total heat production of the subjects at selected 48-hour periods throughout the study. It was found that the specific dynamic effect on the high protein diet which furnished about 122 gm of protein per day was about 8 per cent higher than that of the low diet where the protein content was only about 34 gm. An average estimate of the specific dynamic effect is 6 to 8 per cent of the sum of the energy expenditure of the basal metabolism and physical activities.

The Total Caloric Requirement

The total Calorie needs of an individual are directly related to the energy expenditures for the basal heat production, for physical activity, and for the specific dynamic effect of food eaten. It is possible to estimate these needs either by the use of the factorial method of calculation or by the use of tables of recommended energy allowances. Both procedures have certain limitations. However, if these shortcomings are realized and the results interpreted in the light of the limitations, an approximate energy requirement obtained by either method can be used satisfactorily.

The factorial method of determining total energy needs

In this method of estimating energy requirement, the caloric need is calculated from the individual's basal metabolism, his physical activity, and the specific dynamic effect of his food. To illustrate the use of this procedure in estimating, the energy need of a young male college student who is 19 years old, weighing 154 lb, and 66 in. tall is used as an example.

Calculation of the energy expenditure for the basal metabolism

The basal metabolism of an individual may be calculated by the use of the simple formula (basal metabolism = kilograms of body weight $\times$ 1 Cal. per hour $\times$ 24 hr per day) which was presented early in this chapter. Using this formula, the first step in the calculation is to convert pounds to kilograms of body weight. The 154-pound college student used in this example therefore weighs 70 kilograms. By the substitution of this value in the formula, the energy expenditure for the basal metabolism of this college man is as follows:

$$= 70 \text{ kg} \times 1 \text{ Cal/hr} \times 24 \text{ hr/day}$$

$$= 1680 \text{ Cal.}$$

Because the metabolic rate is lower than the basal during sleep, a correction must be made for the hours of sleep. From the activity list given on the following page, it can be found that this student slept

rs per week, or about 8 out of 24 hours. The formula for the ion for sleep is 0.1 Cal. × kilograms of body weight × number rs of sleep. After the substitution of numerical values in this a (0.1 Cal. × 70 kg × 8 hr = 56 Cal.), the 56 Cal. difference e deducted from the calculated basal metabolism for a 24-hour

ulation of the energy expenditure for physical activities. In to estimate the energy expenditures for the physical activities individual, it is necessary to keep an accurate record of the nd duration of all activities. There are two limitations, how- n the calculation of this part of the total energy need. First, it cult to determine correctly the amount of time spent in any , and second, data on the caloric expenditure for different and intensities of activities are limited. It has been suggested energy expenditures of activities were expressed in Calories per rather than Calories per hour, there might be less error in- because few activities are carried on steadily for long periods e (*1*). The development and the use of the respiratory gas- for determining the caloric expenditures for activity, rather he Douglas method, has increased the variety of kinds and in- s of activities which can now be measured satisfactorily (*1*). ng the energy expenditures per hour under different conditions scular activity given in Table 11, the Calories used for physical y by the college student can be estimated. The number of es used for an activity per hour per unit of body weight, multi- by the number of hours of performance and the kilograms of weight, give the energy expended for a particular physical y. A list of the student's activities for a seven-day period fol-

Sleep	56.0 hr/week
Dressing and undressing	9.1
Eating meals and snacks	14.2
Sitting in classes	20.6
Standing in chemistry lab.	5.1
Running with the track team	6.0
Swimming	1.5
Studying	27.7
Typing course assignments	3.7
Walking	10.1
Walking rapidly	1.7
Driving an automobile	10.1
Attending movies	2.2
	168.0

The caloric expenditure for the physical activities of this [illegible] college student is estimated then as follows:

	Cal. Used for Activity, Cal./hr/kg	Time Spent, Hr	Energy Expended, Cal.
Dressing and undressing	0.7	9.1	[illegible]
Eating meals and snacks	0.4	14.2	[illegible]
Sitting in classes	0.4	20.6	[illegible]
Standing in chemistry lab.	0.5	5.1	[illegible]
Running with the track team	7.0	6.0	[illegible]
Swimming	7.9	1.5	[illegible]
Studying	0.4	27.7	[illegible]
Typing course assignments	1.0	3.7	[illegible]
Walking	2.0	10.1	[illegible]
Walking rapidly	3.4	1.7	[illegible]
Driving an automobile	0.9	10.1	[illegible]
Attending movies	0.4	2.2	[illegible]
Energy expended in physical activity			127.6
per week = 127.6 Cal./kg × 70 kg (body weight)			8932 or 1276.0 per day

Estimation of the specific dynamic effect of food eaten. The estimation of the specific dynamic effect of the food eaten is one of the limiting factors in the determination of the total energy need. At this time, however, it seems appropriate to allot between 6 and 8 percent of the sum of the energy expenditure of the basal metabolism and physical activities for this factor (Table 12).

Table 12. The Daily Total Energy Expenditure of a Young Male College Student as estimated by the Factorial Method

	Calories	Sum of Calories
1. The basal metabolism	1680	
a. Correction for sleep	−56	1624
2. The caloric expenditure for physical activities	1276	2900
3. The allowance for the specific dynamic effect of food (0.06 × 2898 Cal.)	174	3074

y total energy expenditure as estimated by the factorial method

daily total energy expenditure of this college student as esti-
y the factorial method, is 3074 Cal. per day (Table 12).

ns of the factorial method

entioned before, the factorial method for estimating the total
need has certain limitations. This method requires an ac-
ecord of the physical activities (external work) and this alone
ult to measure. Moreover, the estimation of the length of
at an activity is performed is not easy, and the Calorie expendi-
f different kinds and intensities of activities are not always
e. In addition, the lack of knowledge of how to assess ac-
the caloric expenditure involved in the specific dynamic
f food is another criticism of this method.

e Use of Tables of Recommended Energy Allowances or Systems for Determining Total Energy Need

her approach to assessing the caloric need of an individual is
accepted tables of recommended energy allowances or systems
have been developed by nutritionists on the basis of research
and their experienced judgment. The table of recommended
ietary allowances, which includes the need for Calories, was
d for use in this country by the Food and Nutrition Board of
tional Research Council (NRC), whereas the Calorie require-
proposed by the FAO (Food and Agriculture Organization of
ited Nations) are designed for use on an international scale (*2*).
gain, as with the factorial method, there are certain limitations
use of either the NRC tables or the FAO system for assessing
need.

ommended Allowances for energy

Caloric allowances recommended by the NRC are presented in
3. One can readily see from this listing that male college stu-
etween 16 and 19 years of age need about 50 per cent more
s than do the coeds of the same age range.

energy needs of children are the same for boys and girls up to
of 13. Allowances for infants after the first month of life
ed on body weight. Up to six months, inclusive, 120 Cal. per
n are recommended; and 100 Cal. per kilogram for 7 to 12
inclusive (Table 13). Between 1 and 3 years of age, 1300
r day have been recommended for good health. Children in

Table 13. The Recommended Calorie Allowances of the NRC

Age, years	Males	Females
0–$\frac{2}{12}$	kg × 120	
$\frac{3}{12}$–$\frac{6}{12}$	kg × 100	
$\frac{7}{12}$–$\frac{12}{12}$	1300	
1–3	1700	
4–6	2100	
7–9	2500	
10–12	3100	2600
13–15	3600	2400
16–19	3200	2300
25	3000	2200
45	2550	1800
65		add 300 for second half of pregnancy
		add 1000 for lactation

From *Recommended Dietary Allowances*, Revised 1958, Natl. Acad. Sci. – Natl. Res. Council, publ. 589, Washington, D.C., p. 18.

the age range of 4 to 6 years and 7 to 9 years have been assessed 17 and 2100 Cal. per day, respectively. Between 10 and 19 years of a the Calories recommended for boys and young men increase fr 2500 Cal. per day in the preadolescent period to 3600 Cal. per day the late adolescent period. The daily energy needs of the adolesce girl, however, have been suggested to be 2500 Cal. in the 10 to age group, 2600 Cal. in the 13 to 15 age group, and 2400 Cal. in t 16 to 19 year group. After the completion of growth, the ener allowances for men and women are listed only at certain age peri (25 years, 45 years, and 65 years). These periods represent t young adult, the middle-aged adult, and the older adult. It has be suggested that the addition to the normal caloric intake of 300 C each day during the second half of pregnancy as well as 1000 C each day during lactation will more than take care of the extra Cal ries needed during these periods of stress.

The FAO system

The need for a system of international energy standards was re ized during the period of the Second World War. In 1950 the Co mittee on Calorie Requirement of the FAO presented a method f assessing the caloric requirement that, with appropriate adjustmen could be applied to different people in different parts of the wor

odern statement of assessing energy needs is highly tentative
en to testing and further research. However, it has been used
torily in providing for the periodic evaluation of the world
tuation as well as in planning for the food production programs
y countries.

itations of the NRC table and the FAO system

caloric allowances as proposed by the NRC table and the FAO
are tentative guides to estimate the energy needs of popula-
nd population groups. They are not directed to individuals.
ost variable factor in estimating energy needs is the difference
sical activity among people. The activity definition of the
rd man and woman" in both the NRC and FAO systems cor-
ds generally to the average activity of the population. In cases
ater activity, the caloric allowances must be increased. The
system suggests that a maximum of 25 per cent increase above
ndard level should account for the extra Calories needed for
ual type of heavy work. For example, 18 year old football
s in the United States may need 1200 more Cal. each day during
ll season than will moderately active men of the same age. In
st to this, caloric levels should be reduced when the activity
than that defined for "the standard man or woman." It has
suggested that the allowance is best judged for adequacy by
t change and status of health.

uide to the Selection of Foods to Meet the Energy Needs of College Men and Women

ll the nutrients, the need for energy is most easily obtained by
ecause all foods carry Calories. As a matter of fact, it is some-
difficult for a person not to exceed his energy need because of
erabundance of food available to people in this country.
rder to show how easily college students may meet their need
lories, servings of some commonly used foods have been listed
ups representing three-fourths, one-half, one-fourth, and one-
of a college student's need for energy (Fig. 30). Two dif-
sets of values are presented because in the age range of 16 to
rs, college men need about 3600 Cal. per day while coeds need
bout 2400 Cal. per day. Even though a particular food that you
eat may not be listed in Fig. 30, it must be remembered that
ds contribute Calories to the "energy bank."

Amount of Food (College Men 16–19 years)	Approximate Fraction	Amount of Food (College Women 16–19 years)
		
		
1½ qt whole milk		1 qt whole milk
4⅓ ounces hamburger 7¼ slices enriched white bread 4½ tbsp. butter 4½ ounces cheddar cheese ⅙ of an apple pie ¼ pint ice cream 4 ounces ham 2¾ cups mashed potatoes		3 ounces hamburger 5 slices enriched white bread 3 tbsp. butter 3 ounces cheddar cheese 4 inch slice apple pie ½ pint ice cream 3 ounces ham 2 cups mashed potatoes

Fig. 30. The amount of an individual food needed to provide a certain fraction of the day's Recommended Allowance of energy for college men and women.

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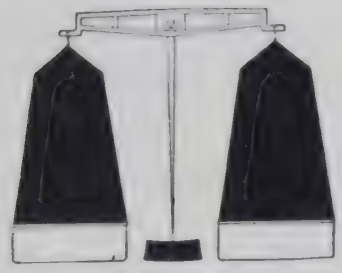
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CHAPTER 8

The energy value of foods



The amount of carbohydrate, fat, and protein in a food determines its energy value. Foods with relatively large proportions of these energy nutrients are rich in Calories while those with small proportions of them are energy-poor (Fig. 31). An ordinary pat of butter, like one that would be served in the college dining hall, has an energy value of 50 Cal. because of its high fat content. In contrast, if one were served a portion of tomato juice equivalent to the energy value of the part of butter, it would take thirty-five times as much of the tomato juice by weight (one cup) to match the number of Calories in the butter.

Determination of food energy

In the laboratory, the *bomb calorimeter* and the *oxycalorimeter* are the two instruments used to determine the energy value of a food. The former one measures the heat produced when a food is actually burned, whereas the latter measures the oxygen used and the carbon dioxide produced during the burning of a food. Because the bomb calorimeter is more widely used in energy determinations of foodstuffs, it will be the only method described here.

The bomb calorimeter apparatus consists of two parts: the bomb in which the food is burned, and the water bath arrangement, which

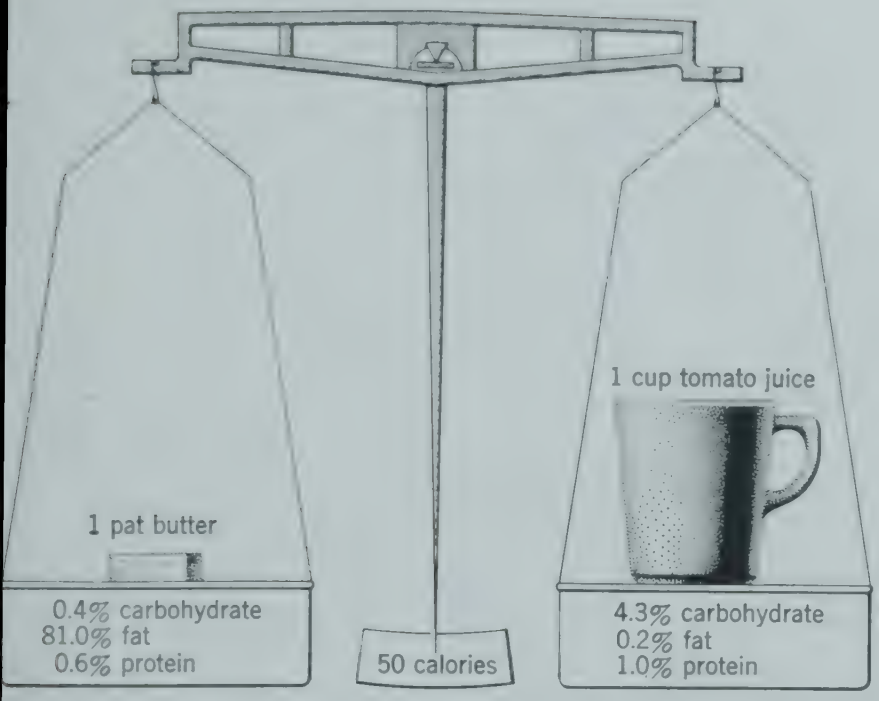


Fig. 31. A comparison of an energy-rich and energy-poor food.

es the heat produced from the combustion (Fig. 32). After nple of food to be analyzed is weighed, compacted, and placed bomb, the two halves of the bomb are screwed together and n is introduced into it. Then, the bomb is placed in the in- water bath which contains a known amount of water. The is agitated by a mechanical stirrer. A thermometer, which can d in a thousandth of a degree interval, is used to measure the rature of the water before and after combustion. The bomb is when an electric current is passed through the fine iron wire hat is attached to the food sample within the bomb chamber. when the excess amount of oxygen present causes complete stion of the food, the heat is conducted from the bomb to the and the increase in temperature is measured. From the temper- readings, the energy value or *fuel value* of the food can be ted. The energy value of foods in food composition tables is on bomb calorimeter measurements.

fuel values of the three energy nutrients, however, are dif- A gram of fat yields 9.45 Cal. whereas only 4.10 Cal. of are obtained when a gram of carbohydrate is burned in the calorimeter. In addition to this, the fuel value of a gram of , 5.65 Cal., is higher than the fuel value of a carbohydrate.

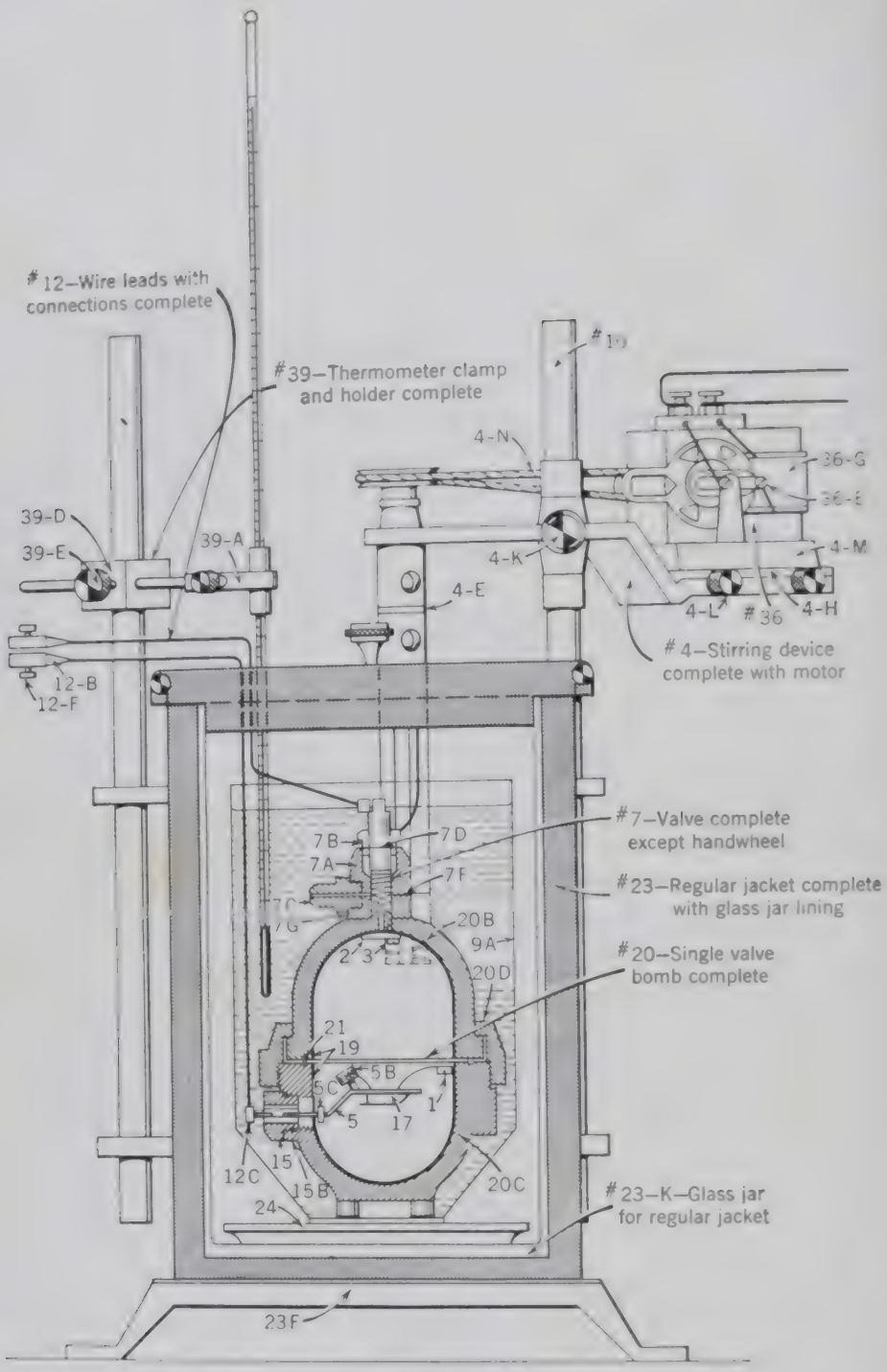


Fig. 32. A cross-section view of the Emerson oxygen bomb calorimeter. (Courtesy of Arthur H. Thomas Co., Philadelphia.)

siological fuel values of foods

animal body does not derive as much energy from the food ts as is released in the bomb calorimeter. During the combus- a food in the bomb calorimeter all the available energy can be ed because the carbon, hydrogen, and nitrogen of the energy ts contained in the foodstuffs are completely changed to the t components: carbon dioxide, water, and nitrous oxide. The however, is not as efficient in its use of food because the energy are not completely digested and absorbed from the digestive and the nitrogen from protein is not completely changed to oxide. For these reasons, the amount of energy that one from the carbohydrate, fat, and protein of the diet is some- ess than the bomb calorimeter fuel values that have been pre- These values, based upon the body's use of energy, are re- to as the *physiological fuel values.*

n one knows the correction factors for the energy losses due incomplete digestion and absorption of energy foods, as well incomplete combustion of nitrogen in proteins, it is easy to cal- the physiological fuel values of the energy nutrients (Table The first step is to subtract 1.25 Cal. per gm from the fuel value

able 14. The Calculation of the Physiological Fuel Values of Carbohydrate, Fat, and Protein

	Carbohydrate, Cal./gm	Fat, Cal./gm	Protein, Cal./gm
ues	4.10	9.45	5.65
e to incomplete combustion of gen			−1.25
	4.10	9.45	4.40
age of digestibility	× .98	× .95	× .92
gical fuel values	4	9	4

tein, which accounts for the energy lost from the incomplete stion of the nitrogen. Because it has been found that about cent of the carbohydrate, 95 per cent of the fat, and only 92 nt of the protein ingested is absorbed by the human digestive nism, the second step in the calculation is to multiply each of maining fuel values by its percentage of digestibility. The alues of 4 Cal. per gm for carbohydrate, 9 Cal. per gm for fat, Cal. per gm for protein are the physiological fuel values that

you can use with reasonable accuracy to calculate the energy conte of any food.

The limitations in the use of the physiological fuel values. Dur and after the Second World War, the first step in the food rehabili tion of the hungry nations of the world was to meet their ener needs. It was found, however, that the energy evaluation procedu used in the United States did not always apply to the national diets other countries. It was pointed out that the physiological fuel val 4-9-4, were based on data applicable only to the foods of the avera mixed American diet and not to single foods or foods of differe mixed diets eaten by other nations. To illustrate the significan of this international problem in planning for the food needs the world population, the example cited concerns the energy val of rice. According to the values 4-9-4, 100 gm of polished rice use in this country averages 351 Cal., while the true values for the sam amount of the undermilled and brown rice used in the Orient average 340 and 320 Cal. respectively. On an international scale where mi lions of tons of rice are involved the 4-9-4 figures would overvalu the caloric content of this food. In order to overcome this proble it was realized that a universal method for the determination and ex pression of food energy values, as well as for other food nutrient was needed. Since that time, several publications have become availa ble which have used specific factors as the basis for the calculations o the available energy in foods.

Calculations of the energy value of foods

Although the physiological fuel values may not be valid for one t use in the calculation of the caloric values of international food sup plies, they are useful for calculating diets in this country. Mo of the foods one eats contains fractions of all three of the en ergy nutrients (Appendix, Table A-5). For example, whole mil contains 4.9 per cent carbohydrate, 3.9 per cent fat, and 3.5 pe cent protein. Yet there are some foods in the diet, such as whi sugar and salad oil, that are rich in just one of the nutrients. Sala oil contains 100 per cent fat, and 99.5 per cent of sugar is in the for of carbohydrate. If the percentage composition of carbohydrat fat, and protein in a food is known, it is easy to calculate its energ value by using the 4-9-4 figures.

To find the caloric value of 50 gm of salad oil, one would fir multiply the percentage of fat in the oil (100 per cent) by the amou of oil (50 gm). The amount of fat is thus found to be 50 gm. Fif times the physiological fuel value of 1 gm of fat (9 Cal.) equa

the caloric value of the oil. If the energy value of 100 gm milk was calculated by using the 4-9-4 values, the procedure as follows:

	Per cent/gm	Physiological Fuel Value, Cal./gm	Cal./gm
ohydrate	0.049	4	0.196
	0.039	9	0.351
in	0.035	4	0.140
			0.687

1 gm whole milk = 0.687 Cal.
100 gm whole milk = 0.687 × 100 = 68.7 or 69 Cal.

for determining the caloric value of a diet

wo ways in which the Calories of the food intake can be d are by bomb calorimeter assays of the food eaten or by ons of diet records from food tables. Although bomb ter measurements are not practical for general dietary use, hod is used in research studies where the exact caloric value ood eaten is important. If, however, a college student wanted the number of Calories that he ate in his food yesterday, one alculate this by using either a long or a short method of analysis. In the long method an accepted table of food values e used to count the Calories contributed by the amounts of vidual foods eaten. The use of a condensed table of caloric n the short method proves to be a time saver in calculating energy.

nteresting to compare the energy values of a typical dinner ng these three methods of evaluation: the bomb calorimeter e long method, and short method of dietary calculation (Fig. he foods analyzed and calculated were ground beef, mashed , green beans, white enriched bread, butter, whole milk, and m. The meal contained 938 Cal. when assayed by the bomb ter, 897 Cal. when calculated by the long method, and the ethod of calculation gave a value of 906 Cal. The bomb ter values for all the foods were higher than the values ob- rom either the long or short method of dietary calculations. or the ground beef sample. This difference is probably be- tra lean round steak was used in the preparation of the meat According to these data there is good agreement among the ethods of caloric assessment even though the calculated values pproximately 4 per cent lower than the bomb calorimeter

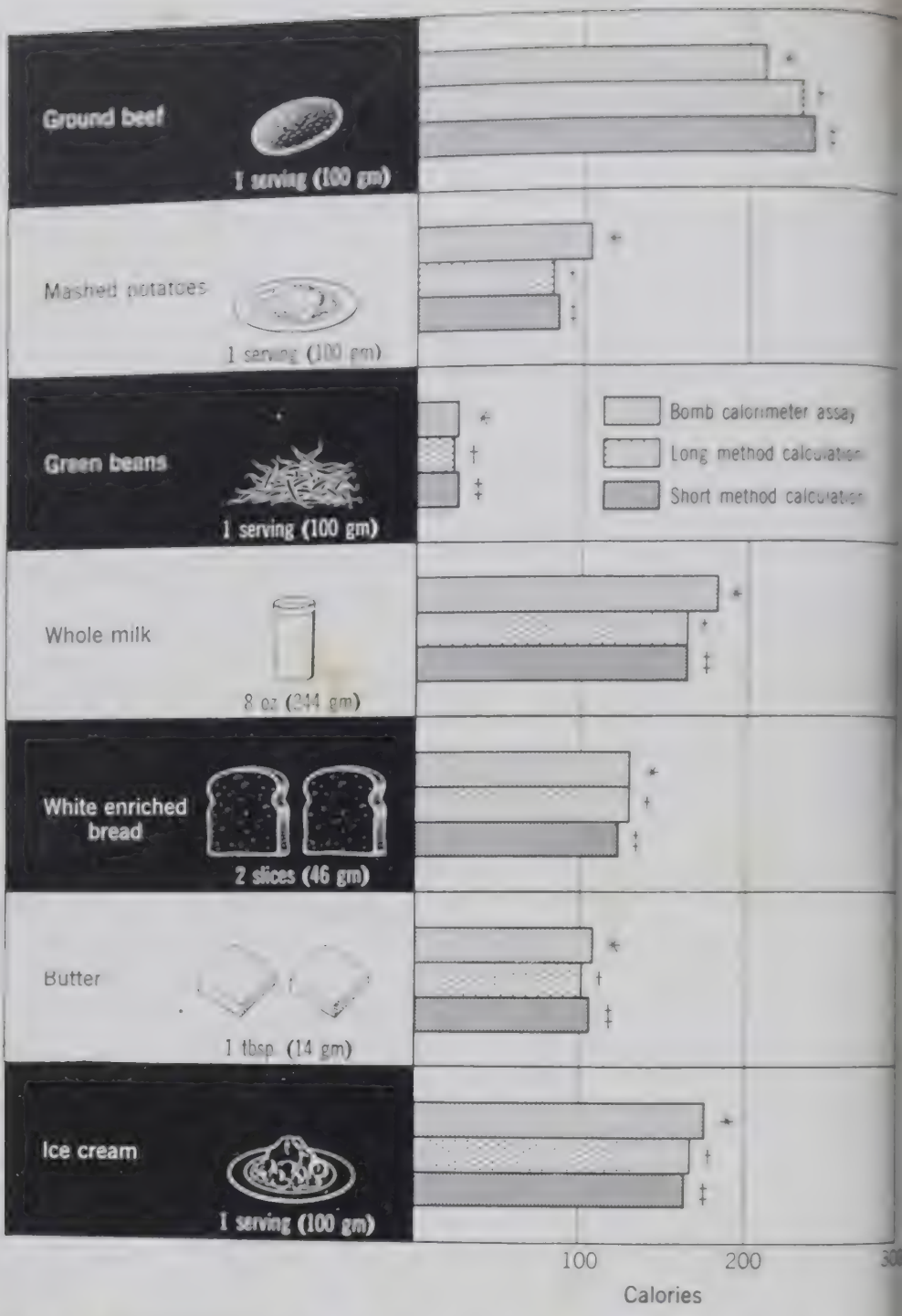


Fig. 33. A comparison of the energy value of a typical dinner meal as asse by bomb calorimeter assays, long, and short methods of dietary calculation.

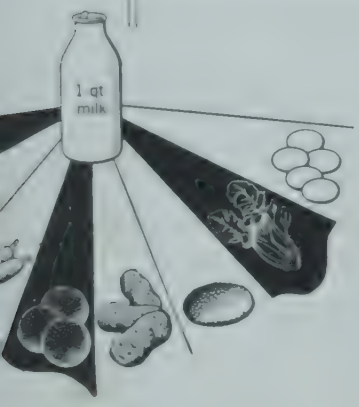
* *Relative Dynamic Effects of High Versus Low Protein Diets of Equi Content.* Pa. Agr. Expt. Sta. Bull. 618, 1957.

† *Composition of Foods Raw, Processed, Prepared.* U.S. Dept. Agr. Handbook 8, 1950.

‡ Food Composition Table for Short Method of Dietary Analysis. *J. Dietet. Assoc.* 27:386, 1951.

PTER 9

Introduction to minerals calcium and phosphorus



Introduction to Minerals

ar we have discussed the organic compounds, carbohydrates, proteins. The elements that make up these and other organic ds in the body, including the vitamins and hormones, are car- rogen, oxygen, and nitrogen, which together comprise the rtion of the body weight (Table 15). The mineral constitu- uding calcium, phosphorus, potassium, sulfur, chlorine, so- gnesium, iron, manganese, copper, iodine, cobalt, zinc, molyb- nd others, account for less than 5 per cent of the body Although present in small amounts, the mineral elements are able to body functioning.

now more about the nutritional significance of some of the than others. All of the nutrients listed in Table 15 have an d purpose in animal nutrition. There has been less extensive with the human, and as a consequence the significance of ments for man is less well established. The study of man's inorganic salts emerged from the work of Osborne and Men- e requirements of the rat (*13*).

Table 15. Elementary Composition of the Adult Human Body

Chemical elements	Percentages
Oxygen	65
Carbon	18
Hydrogen	10
Nitrogen	3.0
Calcium	1.5–2.2*
Phosphorus	0.8–1.2†
Potassium	0.35
Sulfur	0.25
Sodium	0.15
Chlorine	0.15
Magnesium	0.05
Iron	0.004
Manganese	0.0003
Copper	0.00015
Iodine	0.00004
Cobalt	tr.
Zinc	tr.
Others found in minute traces	

* Estimates of normal calcium content vary widely.

† Phosphorus varies with calcium. (Adapted from Sherman, *Chemistry of Fo and Nutrition*, 8th ed., The Macmillan Co., New York, p. 227, 1952.)

Few of the mineral elements exist as such in our food supply, b occur as components of organic compounds. Sodium chloride, o dinary table salt, is an exception; it is an inorganic compound. W may liken the mineral elements to the ash remaining after coal wood has been burned. In fact, the minerals are often referred as *ash* constituents. In the body the minerals provided in foods r main after the organic compounds of which they are a part have be oxidized.

Functions of the Minerals

The mineral elements function in two general roles, as buildi substances, and as regulatory substances. As structural constituent they serve in three general ways:

(*a*) As building constituents in the hard tissues of the body, t bones and teeth, giving rigidity to these structures.

(*b*) As components in soft tissue; muscle protein contains sulfu other substances in muscle tissue contain phosphorus; nervous tiss contains phosphorus.

n compounds essential to the functioning of the body; iodine
t in thyroxin; zinc in insulin; cobalt is a constituent in vita-
sulfur in thiamine; iron is present in hemoglobin and other
nds in tissue cells.

nstituents in body fluids, the minerals have important regula-
ctions. Some of the ways in which minerals aid in the regu-
body processes follow:

ontribute to the osmotic pressure of body fluids. Sodium
undant in extracellular body fluids, and potassium salts be-
their presence in intracellular fluids are of particular impor-
their influence on osmotic pressure. As a consequence they
ne movement of water in and out of tissues. The exchanges
within the body are of fundamental importance; dependent
is physiological function is the absorption of nutrients, the
n of waste, and the functioning of muscles and nerves.
Contribute to the maintenance of approximate neutrality in
od and body tissues by helping to protect against either the
ation of too much acid or too much base (alkali). The
reaction of the body is near neutral, slightly on the basic side.
ief base-forming elements are: sodium, potassium, calcium,
gnesium. The acid-forming elements are chlorine, phospho-
sulfur.
Make possible normal rhythm in the heart beat. The role of
al minerals in heart muscle action was demonstrated in a
xperiment using a frog's heart removed from the body. The
uscle could be made to continue to contract and relax if artifi-
ulation of a solution containing calcium, potassium, and so-
as maintained. If calcium salts were removed from the solu-
muscle failed to contract. On the other hand, if the concen-
f calcium salts was too great, a state of continuous contraction
um rigor resulted. An excessive concentration of potassium
continuous and extreme relaxation—potassium inhibition. A
ment, sodium, was essential in the solution for the muscle to
to contract and relax. However, when sodium salts alone
esent in the solution, relaxation of the muscle took place.
sence of these minerals in proper proportions makes possible
hm characteristic of heart beats.
Help to maintain a normal response of nerves to stimuli. Cal-
the mineral that functions in this capacity. Discussion fol-
h other functions of calcium.

(*e*) Essential for blood clot formation. Calcium is one of the ... stances necessary for the series of changes that normally take ... at the site of an injury resulting in clot formation. Discussion fol... with the other functions of calcium.

Calcium

The body contains more calcium than any other mineral. Cal... accounts for approximately 2 per cent of the body weight, w... amounts to about 2 to 3 pounds in an adult. About 90 per cent ... more of the total amount in the body is concentrated in the bones ... teeth; the remainder is in the fluids and soft tissues.

Functions of calcium

Calcium serves two important functions in the body, the build... of bones and teeth, and the regulation of certain body processes. T... need for calcium for building the skeletal structure is of cou... greater during the years of growth, but the need does not cease wh... full growth is attained. Once bone is formed, it begins a continu... state of change, with processes of building new bone and destroy... old going on simultaneously. Regulatory functions are carried on ... calcium in tissue and blood. Normal behavior of heart muscles, ... nerves, and the process of clotting blood, all depend on the prese... of calcium.

Building bones and teeth. Calcium, together with other mine... elements, gives rigidity and permanence to bones and teeth. Th... characteristics make it possible for bone to be the support of t... body, providing the rigid structure to which muscle tissue is attach... Bone forms protective cavities for vital organs—heart and lungs ... the chest cavity, the brain in the cranial cavity. Although bone w... withstand almost as much weight as cast iron before breaking, it ... light in weight.

Mineral elements present in bone in addition to calcium are ph... phorus, magnesium, sodium, fluorine, and others. Calcium compri... about one-fourth the dry weight of bone, phosphorus about 10 p... cent, and other minerals are present in lesser amounts.

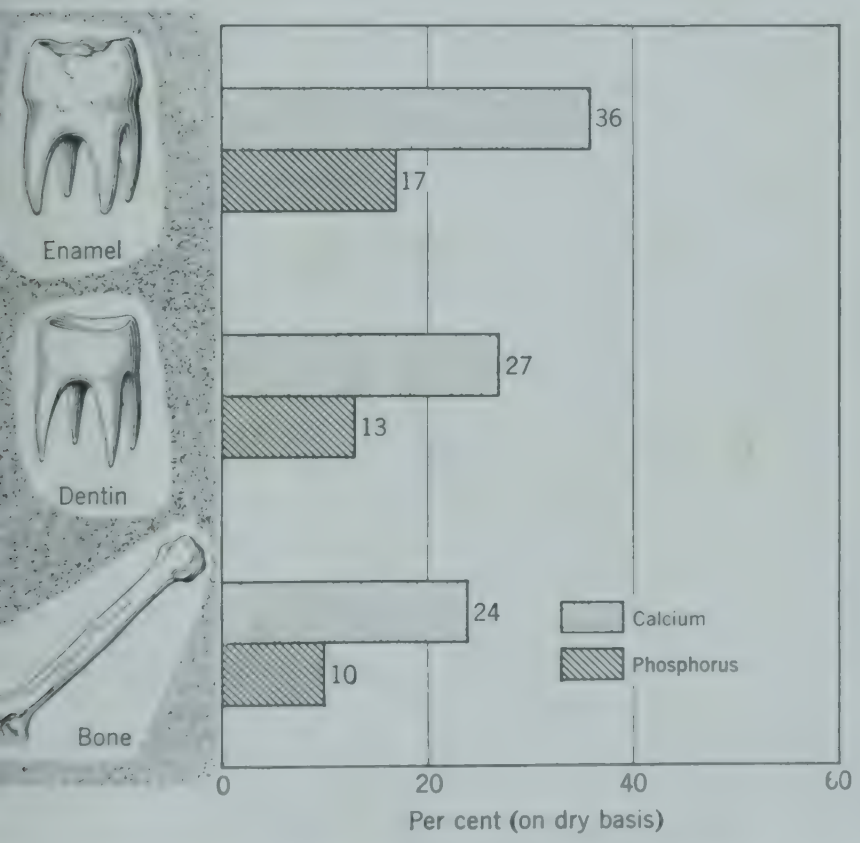
The minerals in bone are deposited in an organic framework ... protein. Minerals comprise 60 to 70 per cent and organic mat... 30 to 40 per cent of the dry bone; fresh bone is 15 to 25 per c... water. The protein is mainly collagen, which is quite insolu... The combination of minerals and organic matter can be read... demonstrated by placing bone in a weak acid solution (ordin...

vinegar can be used), which dissolves the salts, leaving the ganic matter in the shape of the original bone.

like bone, contain both inorganic and organic matter, with anic portion comprising the major part. *Enamel*, the outer- ering, is approximately 99.5 per cent inorganic matter; he portion beneath the enamel and surrounding the tooth ut 77 per cent; and *cementum*, the calcified portion cover- root of the tooth, is approximately 70 per cent inorganic

l, the hardest tissue in the body, contains 36 per cent calcium er cent phosphorus, more of the minerals than is contained ther tissue. Dentin is 27 per cent calcium and 13 per cent us (Fig. 34). Although it appears that minerals of the tooth le to some extent, unlike bone, the enamel of the tooth has no for repair after a portion has been injured mechanically or decay) (*11*).

rganic matter of teeth is chiefly protein. In enamel the pro-



The average calcium and phosphorus content of enamel, dentin, and dapted from Harrow and Mazur (1954). *Textbooks of Biochemistry*. . B. Saunders Co., Philadelphia, p. 413.)

tein is a *keratin*, the most insoluble of proteins. In dentin, like b
the protein is collagen.

Regulating certain body functions. For the heart muscles to c
tract in a normal fashion, the tissue fluid that bathes them must c
tain an adequate amount of calcium.

The amount of calcium in the blood and tissue fluid influences
response of nerves to stimuli. When the amount is abnormally l
hyperexcitability of the nerves occurs. Hypersensitive nerves ca
late the muscles to contract repeatedly with twitching, cramps,
convulsions, a condition known as tetany. Injections of calcium
magnesium) into the blood relieves the symptoms. Before vita
D (which is essential for the utilization of calcium) was known
widely used in the diets of infants, the tetany of rickets was comm
today it is of rare occurrence.

Calcium is necessary for blood clot formation. The process
blood coagulation is complex, involving, in addition to calcium, m
different compounds. That calcium is indispensable in the pro
can be clearly demonstrated by adding oxalic acid to a blood sam
The oxalic acid forms an insoluble salt with calcium so that the
cium is unavailable for use in the coagulation process. As a co
quence the blood will not clot.

Absorption, Utilization, and Excretion of Calcium

Most of the absorption of calcium into the blood takes plac
the upper part of the small intestine. The somewhat acid condi
of the food mass that enters the small intestine favors absorption
helping to keep the calcium in solution. Calcium salts are not rea
soluble in an alkaline medium such as exists in the lower small intes

Many factors affect the absorption and utilization of calcium (
The age of an individual and his need for calcium make a differe
In addition, certain factors in the diet influence the utilization
calcium; vitamin D, protein, and an adequacy of all nutrients in
diet, favor the absorption of calcium. Oxalic acid and phytic a
constituents in some of the foods commonly included in the
interfere with its absorption.

Young children retain a higher percentage of the calcium in t
diets than do adults. Absorption is variable among individuals, v
infants retaining 50 to 70 per cent of the calcium in human m
children from 4 to 12 years of age are found to retain 16 to 34
cent of the intake (7). Adults retain around 20 per cent of
calcium in the diet. The need for calcium imposed by the very n

f childhood must be responsible for the better utilization of
m in the diet.

r cent of calcium absorbed when the intake has been low
be greater than if the intake has been generous in amount.
ervative use of the nutrient when limited in supply is of
ractical significance. Many people in the world have only
amount of calcium in their diets. The response is different,
if the individual has suffered dietary inadequacies to the
being *undernourished*). Stearns found in her studies with
ourished adolescent girls that they were unable to absorb
s efficiently as their well-nourished counterparts. She felt
lessened absorption was due to "decreased efficiency of the
estinal tract" as a result of suffering inadequate nutrition
considerable part of their childhood)(*12*).

the diet favoring utilization of calcium

D. Vitamin D is of *first importance* in the utilization of
by infants and young children. On the other hand, its
ce for adults has not been established. Without vitamin
a generous intake of calcium and phosphorus will fail to
rmal bone formation during early childhood. For children
age and adolescents, vitamin D favors efficient utilization
n by improving absorption from the intestine. The older
are not as dependent on the vitamin as the younger ones.
lts, even young adults, absorption and retention of calcium
lly unaffected by the addition of vitamin D to their diets (*9*).

Utilization of calcium is favored by protein in the diet.
g a low protein intake improves absorption. It seems likely
presence in the small intestine of a greater abundance of
ids from the more liberal protein intake may be associated
better absorption (*3*).

c acid. Findings have varied as to the influence of ascorbic
calcium utilization. There is recent evidence from studies
ge women that the retention of calcium is improved by in-
he ascorbic acid intake to an adequate level when the amount
n in the diet is limited (*6*).

cy of diet. Diets that meet the Recommended Allowances
utrients favor the utilization of calcium. In a study with
omen (*8*) the utilization of an equal amount of calcium
s that were controlled and adequate, and those that were
osen and variable in nutrient content, was compared. The
adequate diet allowed for more efficient utilization of

calcium, particularly if the amount of calcium in the diet was le
the Recommended Allowance.

Factors of the diet interfering with calcium utilization

Oxalic acid. Oxalic acid, an organic acid found in some vege
and other foods, combines with calcium to form insoluble ca
oxalate, which cannot be absorbed. Among the foods conta
oxalic acid are beet greens, chard, rhubarb, spinach, and coco
lower than average grade. When these foods are included i
dietary, some interference with the absorption of calcium is t
expected.

To determine if any of the calcium in spinach could be abso
numerous balance studies have been done with spinach as the
source of calcium in the diet. The findings have been in agree
that the calcium in spinach cannot be absorbed (*4*), which doe
mean, however, that spinach must be abandoned as a food.
exceedingly rich in vitamin A value and iron content. Other f
can be included in the diet to provide the needed calcium.

The effect of cocoa on calcium utilization has been of parti
interest because of its use with milk in beverages. The adverse e
of cocoa on calcium utilization was first observed in studies usin
perimental animals. Oxalic acid was identified as an interfering
stance in cocoa. The amount of cocoa fed to the animals, how
was far above the relative amount customarily consumed in the hu
dietary. So it was with much interest that the effect of coco
calcium absorption in the human was sought. The question wa
vestigated at the University of Illinois (*1*). College women
fed cocoa in amounts varying from approximately three-fourths t
spoon (5.6 gm), to a little more than one-half cup (58.2 gm) d
The calcium content of the diets varied from 21 mg (milk-free
to 755 mg (a diet containing milk and ice cream). The cocoa ha
discernible deleterious effect on calcium utilization in these stu

Phytic acid. Phytic acid, like oxalic acid, interferes with the
sorption of calcium by forming an insoluble calcium salt. Ph
acid occurs in whole grain products, located in the outer bran la
If the diet is adequate in calcium, however, there need be
concern that the phytic acid in the diet will have a detrimental e
on calcium absorption (*2*).

Storage of calcium

Bone serves as the storage place for calcium. The reserve su
is in the inner surface of the ends of the long bones. When cal

d in the tissues or the blood, the labile stores in the bones
n upon.

of calcium

m is excreted in the urine and feces. All of the calcium in
e has been absorbed into the blood stream previously. A
nount of the calcium in the feces has been absorbed earlier,
later returned to the intestine, chiefly by way of the digestive
he remainder of the fecal calcium has never been absorbed.
bunt of calcium in the fecal excretion exceeds the urinary as
although the amount in both pathways of elimination is in-
by the amount in the diet, the fecal more directly than the
Higher intakes are as a rule accompanied by higher
ns.

mount of the urinary excretion differs widely among in-
s but shows a characteristic constancy within each person (5).
ount excreted is influenced to some extent by the calcium
of the blood. If the blood calcium is above normal, the
emoves more by way of the urine; if low, less is removed.

nce of Amount of Calcium on Nutritional Well-being

oved intake

f practical significance to know whether benefits are realized
asing the calcium intake when the amount in the diet allows
ormance accepted as normal. Sherman did research on this
using rats as experimental animals. Calcium added to the
roduced beneficial effects. The unsupplemented ration had
equate for what was considered normal growth, reproduction,
th of life. However, by increasing the amount of calcium
iet by 75 per cent, growth was more rapid, the duration of
to reproduce longer, and the animals lived a longer life
). With these, as with other studies with animals, there are
ons for the human, but of course direct application cannot

equate intake

cient calcium in the diet limits growth in the young. The
effect has been demonstrated in animal studies. In one such
tion twin rats were fed identical diets of meat and wheat
hat a supplement of milk was added to the ration of one.
ilk was added to the diet, the animal received many nutrients

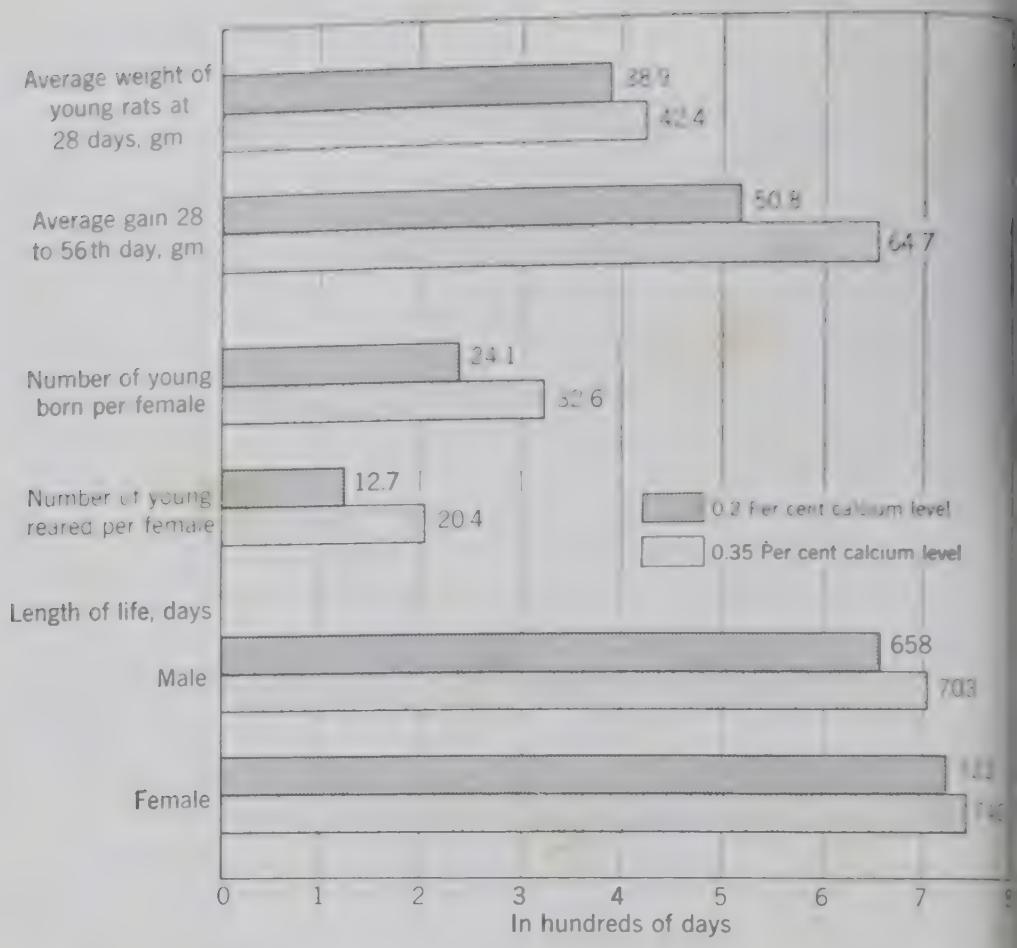


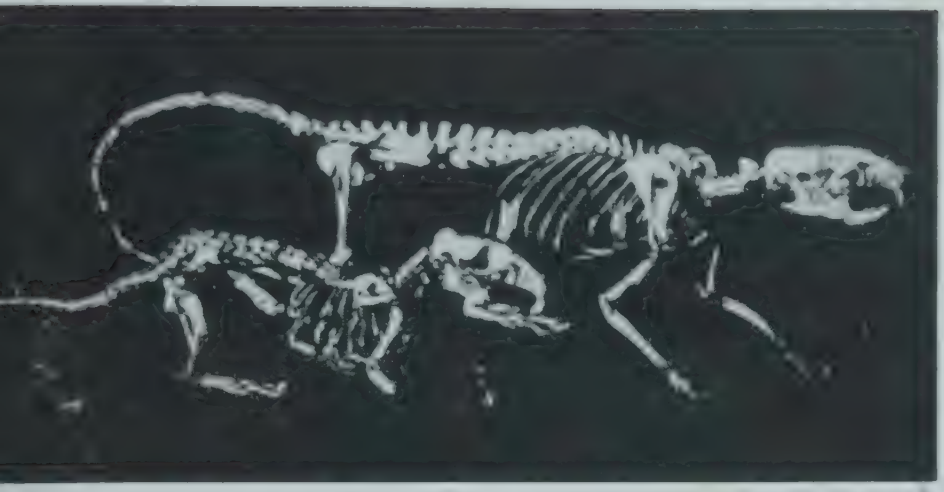
Fig. 35. Influence of increased intake of calcium on behavior of experimen rats. (Adapted from Sherman (1952). *Chemistry of Food and Nutrition.* ed., The Macmillan Co., New York, p. 266.)

in addition to calcium. However, of them calcium was the eleme lacking in the original diet that was most needed for bone develo ment. The skeletal growth of the rat with the added milk exceede notably that of the rat without (Fig. 36).

Recommended Allowances for calcium

The calcium balance study (Fig. 37) is the customary method us for estimating the amount of calcium needed to satisfy the da requirement. The approach to determining calcium needs for ch dren differs from that for adults. For children the intake at whi maximum retention occurs is recommended in order to make allo ances for growth. For adults, the least intake that will assure a p itive balance is considered sufficient.

The Recommended Allowance for calcium in late adolescence a



Twin rats showing the effect on skeletal size of the addition of milk
et. (*J. Biol. Chem.* 60:5, 1924.)

dulthood is 1.4 gm daily for young men and 1.3 gm daily for
women. The continued high intake recommended for the 16
ears of age period satisfies the demands for growth which
e young people is still great. For others, whose growth has
off, the generous intake affords an opportunity for them to
p whatever deficits in calcium intake they may have suffered in
ceding years.
adults the Recommended Allowance is 0.8 gm daily. The



A group of students who are subjects in a calcium balance study.
y Patton, Ohio Agr. Expt. Sta., Columbus. Photo by The Ohio State
ty.)

amount must be increased of course for women during pregnancy a
lactation. The amount of calcium needed during the childhood ye
exceeds the need of adults, sharply emphasizing the demands impos
by growth.

In summary, there are two fundamental factors that give rea
for maintaining an intake of calcium that meets the Recommend
Allowance. In the first place, wide differences exist in the capac
of individuals to utilize calcium; some people use it efficiently, othe
do not; the difference is not outwardly recognizable. Further:mo
factors adverse to calcium utilization that may characterize the d
are least detrimental when the intake of calcium is adequate.

Food sources of calcium

Few foods available to us are excellent sources of calcium. Mi
and milk products are the most dependable ones. Fluid skim m
and nonfat milk solids have the added recommendation of bei
economical in cost. Without milk or milk products in the diet it
difficult to provide the Recommended Allowance for calcium; i
cluding them in reasonable amounts practically assures meeting t
allowance. In late adolescence or early adulthood, $1\frac{1}{2}$ pt of milk
its equivalent in the diet is usually sufficient along with the other foo

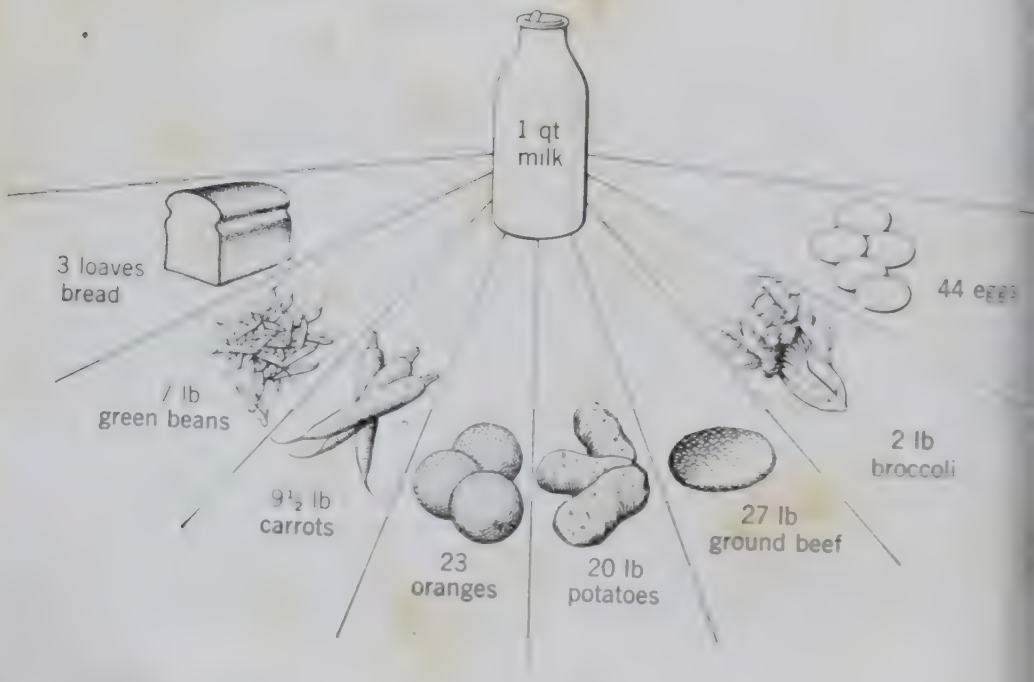


Fig. 38. Quantities of different foods that supply calcium equivalent to one qu
of milk.

the allowances. For adults, a pint of milk is sufficient. Figure trates the relative superiority of milk as a source of calcium as ed to other foods.

n leafy vegetables (excluding members of the goosefoot family, spinach, and chard that contain oxalic acid) rank next to the roducts in calcium content. Broccoli is a good source; citrus nd legumes are fair sources; meats, grains, and nuts provide the alcium. The incorporation of milk in the bread formula im- this product as a source of calcium.

calcium content of an average serving of some common foods in Table 16.

Table 16. Calcium Values of Some Typical Foods

Food	Measure	Calcium, mg
ilk	1 cup, 8 oz	288
eese, American cheddar	1 oz, 1 cu in.	206
ustard greens	⅔ cup	205
le	⅔ cup	165
occoli	⅔ cup	130
eam, light	7 tablespoons	105
cream	⅐ quart	100
ked beans (with molasses)	⅔ cup	97
ttage cheese	¼ cup	54
anges	1 medium	51
ma beans	⅔ cup	31
een beans	⅔ cup	30
g	1 medium	26
as	⅔ cup	23
anut butter	2 tablespoons	24
ead, whole wheat	1 slice	22
ead, white, enriched	1 slice	18
tmeal	⅔ cup	14
tato	1 medium	13

Composition of Foods—Raw, Processed, Prepared. U.S. Department of ure, Agriculture Handbook 8, 1950.

mes when there are certain dietary restrictions or a need for beyond that supplied by food, physicians may recommend of calcium salts. Numerous studies have been done using lts as calcium gluconate, lactate, carbonate, and sulfate, with neral finding that calcium from the salts tested is utilized to mately the same extent as that in milk.

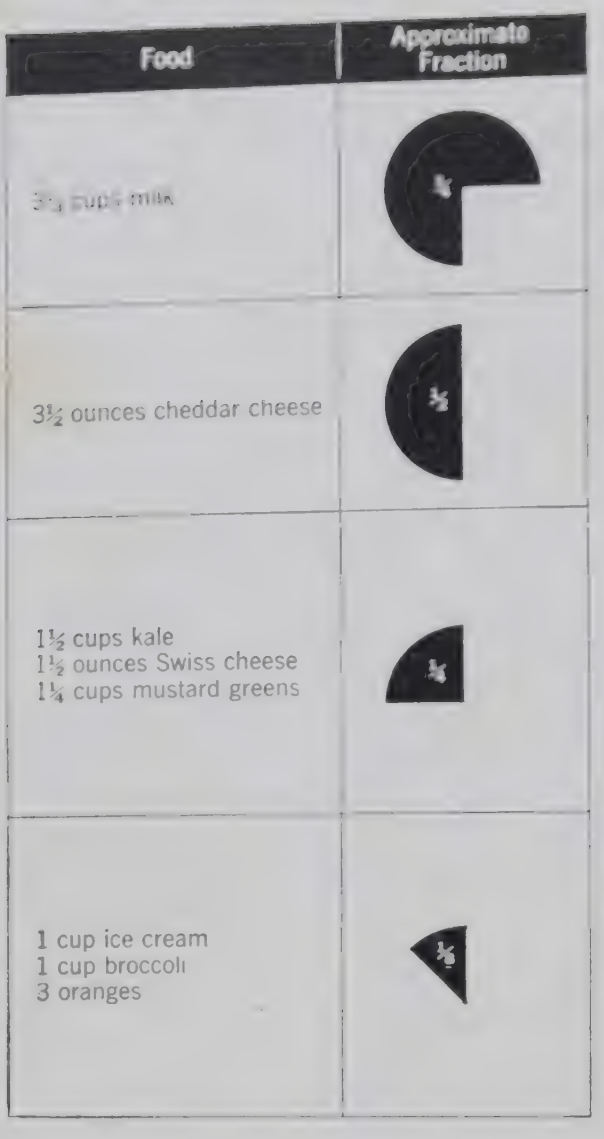


Fig. 39. The amount of individual food needed provide a certain fraction the day's Recommended lowance of calcium for lege students.

A guide to meeting the daily need for calcium

Unless care is exercised in the selection of foods, diets tend supply less than the recommended amount of calcium. In Fig. fractions of the daily calcium needs of college men and women pr vided by common foods are given. For an adequate intake, enou of the fractions must be included in the diet to make a *whole*.

Phosphorus

Phosphorus is an important constituent in every tissue in the bod The total amount constitutes about 1 per cent of the body weig Ranking second among the minerals, phosphorus is exceeded amount in the body by calcium only. It occurs in bones and teeth

nation with calcium and in fluids and soft tissues as a con-
nt of many compounds essential in active metabolism.

ons of phosphorus

sphorus combines with calcium to form a relatively insoluble
ound which gives strength and rigidity to bones and teeth. The
nt of phosphorus in bone is about half that of calcium. Al-
h the extent of mineralization of bone may vary, the calcium
sphorus ratio is rarely altered.

sphorus, like calcium, is needed not only for growth and
opment of the skeleton, but also for its maintenance. Studies
radioactive phosphorus confirm the belief that the minerals of
are in constant turnover. In comparable studies, it was found
ome mineral exchange takes place in the teeth also. Phosphorus
amel interchanges with phosphorus in the saliva; dentin ex-
ges phosphorus with the blood supply in the tooth.

e full importance of the role of phosphorus in the functioning
body has been realized only within the past 20 years or so. The
cance of phosphorus cannot be overemphasized, for the meta-
processes of all cells and the utilization of many nutrients that
the body involve the formation and degradation of phosphorus-
ining compounds. It is a component of enzyme systems essential
sue respiration. A series of phosphorus compounds are formed
e utilization of carbohydrate. Fatty acids combine with phos-
s as a step in their use by the body. Phosphorus-containing
genous compounds are broken down and rebuilt in the complex
ss of muscle contraction. It is apparent that phosphorus is vital
e fundamental processes of metabolism in the body.

ption and excretion of phosphorus

sphorus is absorbed in the small intestine, with more complete
ption than for calcium. The kidney is the major pathway of
tion of phosphorus, influenced to some extent by the amount
bed from the intestinal tract.

encies of phosphorus

are not concerned with phosphorus deficiencies in the human
se diets are seldom, if ever, inadequate in this nutrient. How-
it has been a common deficiency in cattle and forage animals.
ore recent years with increased knowledge of animal feeding,
ements are given to livestock to provide a more complete
al ration. Animals suffering with phosphorus deficiency de-

velop stiff joints, and the bones become fragile and break easily. F perimental phosphorus deficiency in rats, produced by limiting intake, slows the rate of growth and causes subnormal deposition calcium and phosphorus in the bones.

Recommended Allowances for phosphorus

Diets that supply the Recommended Allowances of calcium protein are quite certain to be adequate in phosphorus. The Fo and Nutrition Board recommends that for adults the phosphor allowance should be approximately one and one-half times that calcium.

Food sources of phosphorus

Phosphorus is widely distributed in both plant and animal food Meats are a good source of phosphorus as are fish. Cereal grains pr vide phosphorus in good amount, whole grain more than the high

Table 17. Phosphorus Values of Some Typical Foods

Food	Measure	Phosphorus, mg
Liver, beef, fried	2 sl., 3″ × 2¼″ × ⅜″	311
Milk	1 cup, 8 oz	227
Lamb, leg, roasted	3 oz., 3″ × 3¼″ × ⅛″	219
Pork chop, loin, fried	3 oz.	200
Beef, round, cooked	3 oz, 4″ × 3″ × ⅜″	191
Haddock, broiled	1 pc., 4″ × 3″ × ½″	182
Baked beans	½ cup	148
Cheese, American cheddar	1 oz, 1 in. cube	140
Cottage cheese	¼ cup	106
Oatmeal	⅔ cup	105
Shredded wheat	1 biscuit	102
Egg	1 medium	101
Ice cream	⅙ quart	93
Broccoli	⅔ cup	76
Lima beans	½ cup	62
Bread, whole wheat	1 slice	60
Corn	½ cup	43
Orange	1 medium	36
Grapefruit	½ medium	34
Bread, white	1 slice	21

From *Composition of Foods Raw, Processed, Prepared* U.S. Department Agriculture, Agriculture Handbook 8, 1950, and Bowes and Church, *Food of Portions Commonly Used*. 8*th* ed. 1956, Philadelphia 6.

product. However, the higher phosphorus content of the grain products may be misleading because of the greater content of phytin phosphorus which is not readily utilized by the body. ed beans and eggs contain appreciable amounts of phosphorus. nd dairy products are excellent sources. Vegetables and fruits, hole, are rather low in phosphorus content (Table 17).

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CHAPTER 10

Iron and iodine

Iron

Iron is of particular importance because it is essential to the process of oxidation in the body. It is this mineral that carries oxygen t every cell. It is not difficult to associate iron with transportation, fo in our everyday world, thousands of miles of iron rails carry cargoe to predetermined destinations.

The total iron content of the body is relatively small. In an adul it is approximately 3 to 5 gm, whereas the total weight of the body i probably 65,000 gm or more. If we wish to visualize that amoun of iron as a lump sum, we may think of it as being around one-tent of a teaspoon.

Functions of iron in the body

Iron is widely distributed throughout the body. The major portio is in the blood, approximately 55 to 60 per cent; muscle tissue contain about 3 per cent, and a variable amount is stored in the liver, spleen kidney, and bone marrow.

In the red cells of the blood. Most of the iron in the blood i located in the red cells (erythrocytes). It is present there in th hemoglobin, a compound formed from the union of an iron-contain ing pigment, heme, and a protein, globin. If there is a deficiency of iron, the amount of hemoglobin that can be formed is limited Even though iron constitutes less than one per cent of the total weigh of the hemoglobin molecule, it is the keystone for its formation.

Soon after its absorption iron is incorporated into hemoglobin

process takes place in the bone marrow where new red cells rmed. The time required for iron ingested in the food to be porated into the red cells has been studied with radioactive iron. se radioactive iron is not found in the body normally, it is le to identify it with certainty, and differentiate it from the from other sources. After radioactive iron was administered venously to nine normal men, some of it appeared within 24 hours e red cells in the blood. By the end of the fifteenth day an ge of 74 per cent of the injected radioactive iron was found in irculating red cells (*1*).

anemic dogs radioactive iron was identified in the red cells as as 4 hours after its ingestion. It means that within those few s the iron had, (*a*) travelled to the bone marrow, (*b*) there it was porated into the hemoglobin portion of new red cells, and (*c*) rned to the circulation.

e may conclude that it takes only a few hours to manufacture red and logically question how long they remain in existence, once ed. The life span of erythrocytes is estimated to be around 120 or less. The number of red cells destroyed each hour is around 36 billion, which is approximately one per cent of the cells. new cells being formed and old ones being destroyed, we can conclude that there is considerable turnover of the cells of the d.

n is not the only mineral necessary for the formation of hemo-n, even though it is the only mineral in the molecule itself. per, too, is essential. This significant discovery was made at University of Wisconsin. For several years the development of ia in young animals (albino rats) restricted to a diet of milk been under study. Copper was found to prevent this anemia; it essential to the formation of hemoglobin, but was not a con-nt in the final product. We can rest assured that in the average d diet that most people eat, sufficient copper is available to pro-for normal hemoglobin formation.

moglobin performs the important operation of carrying oxygen the lungs to the tissues. In the lungs hemoglobin combines y with oxygen to form *oxyhemoglobin*, which carries the oxygen e tissues and releases it there. In the lungs there is an abundance ygen, which facilitates the combination of atmospheric oxygen hemoglobin. In the tissues there is little oxygen, and a need exists, so it is readily released. Hemoglobin from which oxygen een released is called *reduced hemoglobin*. The reduced hemo-n then returns to the lungs by way of the venous circulation

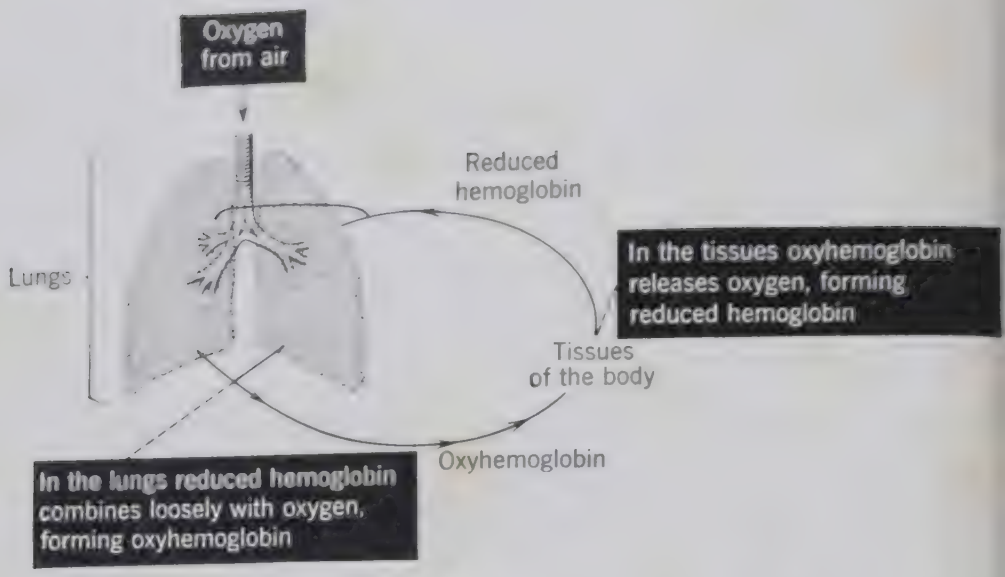


Fig. 40. Diagrammatic schedule of the oxygen-carrying function of hem globin.

to again pick up oxygen in the formation of oxyhemoglobin, and th cycle is repeated (Fig. 40).

In the blood plasma. There is a small amount of iron in the plasm It accounts for only about two tenths per cent (0.2 per cent) the total iron in the blood. Iron in the plasma is in transport. may be newly absorbed iron, or iron moving from storage on i way for use by the body, for excretion, or for deposit for later us Iron travels in the plasma bound to a protein, a specific globulin.

Plasma iron arises from three sources, (*a*) that absorbed from th gastrointestinal tract of dietary origin, (*b*) that salvaged from th breakdown of hemoglobin, and (*c*) that released from stores in th body. In the normal individual the destruction (hemolysis) of re cells contributes by far the largest amount of iron of the three source It has been estimated that about 27 to 28 mg of iron per day com from that source in the average man, whereas only about one mill gram comes directly from food (*6*). The amount used from storag is widely variable and depends on the need of the individual.

The level of iron in the plasma is considered a sensitive index the state of iron metabolism in the body. Plasma iron determination however, are not often used in the usual clinical laboratory in diag nosing iron deficiency. Instead, the common practice is to dete mine the hemoglobin level and red cell count, which also give in formation on the status of the iron metabolism. Under norma conditions the plasma iron level may vary from 50 to 180 mcg per 10

plasma. In iron-deficiency anemia, the level is reduced. On er hand, there are certain abnormal conditions, such as excessive tion of red cells, in which there is a pouring out of iron d from the cells.

uscle tissue. Iron is present in the muscle cells in two combina- s (*a*) myoglobin and (*b*) as a constituent of certain enzymes. on in these tissue compounds seems to be constant in amount, eldom drawn upon for other uses.

globin is a compound similar to hemoglobin in structure and in n. Like hemoglobin it is formed from the combination of an ntaining pigment and a protein, and is a carrier of oxygen. obin has the capacity of storing oxygen in the muscles for use cle contraction.

iron-containing enzymes in muscle make possible the oxidation ohydrate, fat, and protein within the intact cell. These en- are the cytochromes, catalases, and peroxidases. Each has the eneral function, but operates in a specific way in bringing he oxidative changes within the tissue. Iron serves in a double y in cellular oxidation; it carries oxygen to the cells and makes e oxidation in the cells through the iron-containing enzymes.

tion, storage, and excretion of iron

rption of iron. Iron is absorbed into the blood stream, chiefly he upper part of the small intestine. It is well established that ount absorbed is regulated to a considerable extent by the need body. This capacity to control absorption is of particular ance, for the body's capacity to excrete iron after it has l the blood stream is almost negligible.

striking finding that some mechanism exists for the control of sorption was conclusively established through one of the most ating techniques in nutrition studies today, the use of radio- elements. An ingenious study was done by Moore and his es at Washington University. Persons in normal health and ith iron-deficiency anemia were fed a diet in which most of the as radioactive. Eggs containing radioactive iron were obtained ecting radioactive iron into the laying hen. Vegetables were in nutrient solutions containing radioactive iron. The normal nd women on diets containing radioactive iron from these absorbed from 1 to 12 per cent of the iron intake; persons on-deficiency anemia absorbed as much as 45 to 64 per cent at ne level of intake. Thus individuals with a greater need for sorbed a greater amount of it (*11*).

The regulatory mechanism for accepting or rejecting iron appe to reside in the mucosa of the small intestine, at the port of entry iron into the blood stream (*4*). One theory, and perhaps the mo acceptable at present, is that there is in the intestinal mucosa acceptor, an iron-free protein (believed to be apoferritin) that h the capacity of combining with iron to form ferritin. When t acceptor becomes saturated, no more of the mineral is absorbe When more iron is required in the body, absorption may then beg again (*5*). The control is not absolute; some persons even thou they appear to have adequate stores of iron are found to absorb t mineral. Also, in studies with experimental animals, it was found th excessive intakes may overcome the regulatory capacity of the sm intestine.

Storage of iron. Iron is stored chiefly in the liver, spleen, a bone marrow. The amount is variable, ranging from 1 to 2 g Storage iron is held in two compounds, ferritin and hemosiderin, bo iron-containing proteins. Iron is first stored as ferritin, and it ferritin that is first withdrawn when iron is needed by the bo marrow. The more stable stores are in the form of hemosiderin.

Excretion of iron. As indicated earlier in the discussion, very litt iron is excreted. Once it has entered the blood stream, the bo holds tenaciously to it. To be sure, iron is excreted in the feces b it arises from the unabsorbed iron from food. The amount of ir that is accounted for by re-excretion from the blood stream back in the intestine is minute. For normal persons it amounts to a proximately 0.02 to 0.05 mg of iron per day (*7, 11*).

A very small amount of iron is excreted in the urine, usually le than 0.2 mg per day. It is evident from the amount excreted th iron liberated from the breakdown of hemoglobin is carefully save and used again. This husbanding of available iron testifies to its in portance in the physiological mechanism of the body.

Loss of blood is really the only way in which significant amounts iron may leave the body after absorption into the blood stream. Suc avenues of loss may be through blood donations, through abnorm hemorrhage resulting from casualties or illness, and in women, throug menstruation.

Menstruation results in an iron loss that is of such magnitude th care must be taken to provide sufficient of the mineral in the diet f replacement. The extent of loss varies widely from person to perso In a study of all of the data in the literature Frenchman and Johnst (*3*) found that almost one-half the women lost one-half milligram less per day; 15 per cent lost more than 1.2 mg per day—an averag spread over all days, not just for the menstrual period.

inadequate iron in the diet

icient iron in the body may result from (*a*) an inadequate (*b*) poor absorption due to some disease complication, or (*c*) al loss of blood from the body. Two forms of iron deficiency mmonly recognized; one is termed *latent*, the other *manifest* iciency. The latent deficiency is not recognized by outward nces, but by the condition within the body, available iron re depleted, plasma iron level is reduced, and the "iron-bind- pacity of the blood is increased—in other words, more of the ar protein that takes on iron is free and uncombined. There iron to combine with it. In manifest deficiency, outward ms are manifested as well as changes in the blood picture. A with manifest iron deficiency is weak, pallid in appearance, s frequent headaches. The hemoglobin level is lower than and the red blood cells are smaller than normal (hypo- microcytic anemia). The condition results in lowered oxy- rying capacity. The limited oxygen supply to the tissues re- the feeling of fatigue that characterizes anemia.

iron and hemoglobin content of the blood in iron-deficiency are markedly reduced. As shown in Table 18, the plasma iron

Table 18. Plasma Iron Level

	Number of cases	Microgram/100 ml
Normal	169	110 ± 31
Iron deficiency	40	26 ± 7

Cartwright, Gubler and Wintrobe, *Methods for Evaluation of Nutritional and Status*. National Academy Sciences—National Research Council, ton, D.C., p. 113, 1954.

ay be reduced to one-fourth that of normal. With hemo- although the level is found to vary widely among apparently individuals, values 25 per cent or more below "normal" are ly considered to indicate a condition of anemia. For men the range is from 14.0 to 18.0 gm per 100 ml; for women it is varying from 11.5 to 16.0 gm per 100 ml (Table 19). It is r persons to know the level of hemoglobin that is normal for when in good health. Deviations can then be more readily ized.

cally, iron-deficiency anemia is found chiefly in infants, young n, and women; rarely in men. Infants and young children ave been fed on cow's milk formulas without sufficient supple-

Table 19. Blood Erythrocyte and Hemoglobin Values

Age	Erythrocyte count, millions/cu mm		Hemoglobin, gm/100 ml	
	Mean	Range	Mean	Range*
End 6th month	4.6	3.9–5.3	12.3	10.0–
End 12th month	4.6	4.0–5.5	11.6	9.0–1
End 4th year	4.7	3.8–5.4	12.6	9.6–1
End 8th year	4.7	3.8–5.4	12.9	10.3–1
End 12th year	4.8	3.8–5.4	13.4	11.0–1
14 years and over				
Males	5.4	4.6–6.2	15.8	14.0–1
Females	4.8	4.2–5.4	13.9	11.5–1

* Ninety-five per cent range. (From Albritton, *Standard Values in Bl* W. B. Saunders Co., p. 38, 1952.)

mentation with iron-containing foods may be victims. In women th condition may occur as a result of large menstrual losses or the in creased requirement for iron during pregnancy. In men, unless ther is some abnormal blood loss, microcytic hypochronic anemia seldo if ever, develops.

Blood donors experience a lowering of the hemoglobin level wi each donation. The decrease may average 2.3 gm per 100 ml o blood with the removal of approximately a pint (555 ml), as found a study of 200 persons at the University of Iowa (*2*). The mea hemoglobin level prior to the donation for this group was 12.8 gm The length of time required for hemoglobin to return to the pr donation level varies with individuals. It may be as short as 2 to weeks for some, or as long as 3 to 4 months for others. The averag time required by the 200 Iowa persons was 50 days. For women th period of recovery is longer than for men. The differences amon individuals is explained on the basis of variability in iron stores.

The administration of medicinal iron and the adherence to certai dietary precautions hasten the restoration of the hemoglobin lev after giving blood. Medicinal iron administered as 1 gm of iro and ammonium citrates per day shortened the period from an ave age 50 to 35 days after the first donation, with progressively le effect after subsequent donations.

Increasing the protein content of the diet was found to haste the restoration of hemoglobin in a study with University of Nebras college women. Diets containing 50, 75, and 90 gm of protein dai were fed to 129 young women who were contributors to the loc blood bank. Only those who received 90 gm of protein daily ha

bin values of the predonation level in six week's time after
d contributed blood (*9*).

r essential dietary nutrients play a role in maintaining the nor-
od picture, including copper, ascorbic acid, and vitamin B_{12}.
nction of each is discussed in their respective sections of the

ended Allowances

National Research Council has recommended a daily intake of
15 mg daily for young people 16 to 19 years of age. For
he amount recommended is less, 10 mg for men and 12 mg for
. The greater allowance for the 16 to 19 year group is needed
care of growth and deficits in iron storage that may have
ed in the preceding years of rapid growth. In girls, in ad-
the onset of menstruation imposes an extra demand for
).

pproach to determining the iron need is measuring the loss
ne body, and the amount in the diet sufficient to replace this
An average value for the total excretion of iron in urine, sweat,
es has been estimated to be 0.5 to 1.0 mg per day (*11*). An
nal 0.5 mg. was assumed to be needed daily by women to take
menstrual losses. As less than 10 per cent of the iron in food
d to be absorbed, on an intake of 15 mg, only 1.5 mg, using
values for the calculation, would be utilized.

adequacy of the diet as a whole makes a difference in the
of iron that is needed. In studies with college women at the
sity of Nebraska, Leverton and Marsh (*10*) found that with
nat supplied an abundance of essential nutrients, as little as 7
iron daily was sufficient on the average to allow for some
of the mineral; with suboptimal diets a loss of iron resulted at
el of intake. However, dietary studies reveal that few persons
food intake that supplies the recommended amounts of all
ts, making it desirable that the iron intake be above the
m.

urces of iron

is an excellent source of iron; other meat products are good
. There is a generous amount of iron in the yolk of egg.
fruits, such as apricots and prunes, are good sources, as are
eafy vegetables, such as spinach. Fresh and canned fruits and
egetables supply some of the mineral but cannot be considered
ources. Enriched and whole grain cereals furnish iron in
s that are significant in the total day's dietary (Table 20).

Table 20. Iron Values of Some Typical Foods

Food	Measure	Iron
Cereal products		
Bread, whole wheat	1 slice	0.1
Bread, white, enriched	1 slice	0.1
Rice, white, cooked	¾ cup	0.4
Dairy products		
Cheese, cheddar	1 cu in.	0.2
Milk, whole	1 cup	0.2
Egg	1 medium	1.3
Fish		
Salmon, halibut, cooked	3 oz	0.8
Fruit, fresh		
Apricot	3	0.5
Orange	1 medium	0.4
Apple, pear	1 medium	0.4
Fruit, dried		
Apricot	½ cup	2.3
Prunes, cooked	8–9 small	2.2
Raisins	½ cup	2.6
Legumes		
Red kidney beans, canned	½ cup	2.4
Meat		
Beef liver, cooked	2 oz	4.4
Beef, pork, cooked	3 oz	2.6
Chicken, cooked	3 oz	1.5
Nuts		
Peanut butter	1 tablespoon	0.3
Molasses		
Light	1 tablespoon	0.9
Medium	1 tablespoon	1.2
Vegetables		
Spinach, cooked	⅔ cup	2.4
Peas, cooked	½ cup	1.5
Broccoli, cooked	⅔ cup	1.3
Carrots, cooked	⅔ cup	0.6
Potato, cooked	1 medium	0.8
Tomato, raw and cooked	1 small, ½ cup	0.7
Head lettuce, cabbage, raw	1 cup	0.5

From *Composition of Foods—Raw, Processed, Prepared.* U.S. Department Agriculture, Agriculture Handbook 8, 1950.

ses is rich in iron content. It may be surprising that a con-
d sweet should be high in iron content. Molasses is the liquor
g after the crystallization of raw sugar from the concentrated
ugar cane. On the market, molasses designated as "light" is
ich comes from the first extraction of sugar. It is less con-
d, and consequently lower in iron content than subsequent
ns. The second extraction is designated as "dark." "Black-
the result of further extraction and although highest in iron
it is not useful in human diets because of the strong flavor.

to meeting the daily need for iron

ixed diet of cereals, milk, meat, vegetables, and fruits is eaten
y, will the iron intake automatically approach 15 mg daily?

Food	Approximate Fraction
3½ ounces beef liver	
8 ounces lean beef 1 cup dried apricots	
¾ cup raisins 4½ ounces ham 1 cup spinach 4 tbsp. molasses	
⅔ cup red kidney beans 1½ eggs 6 cooked prunes 4 slices whole wheat bread	

The amount of an individual food needed to provide a certain fraction
y's Recommended Allowance of iron for college men and women.

The fraction of the amount furnished by a serving of commonly used foods is shown in Fig. 41. In order to assure meeting the Recommended Allowance foods that are *good* sources of iron must be eaten daily. In addition, *excellent* sources such as liver and green leafy vegetables, should be included frequently.

Iodine

Iodine is recognized as an important dietary nutrient, chiefly because normal functioning of the thyroid gland depends on an adequate supply of it in the body. In this country we have concerned ourselves seriously with making certain that the intake of iodine be sufficient to prevent the damaging effect of long continued iodine deficiency. Retardation, not only in physical development, but mental as well, results when generations are subjected to an insufficient intake of iodine (*1*).

Location in the body

The amount of iodine in the body is infinitesimally small, with most of it concentrated in the thyroid gland. In terms of body weight the iodine content is estimated to be about 0.00004 per cent or approximately 28 to 30 mg in the adult.

Although most of the iodine is localized in the thyroid gland, the remainder is widely distributed throughout the body. In fact, all tissues and secretions that have been analyzed for iodine are found to contain some of it. The thyroid gland is located at the base of the neck. It consists of two lobes, one on either side of the trachea, connected by an isthmus across the front of the trachea. Normally the gland weighs from 20 to 25 gm. It is enough to say at this time, that with an insufficient intake of iodine the gland enlarges and may prove to be an obstruction to normal respiration.

The thyroid is one of several endocrine glands. They are sometimes designated as *glands of internal secretion*, or *ductless glands*. Each manufactures one or more secretions which it pours directly into the blood stream. The secretions of the endocrine glands are known as hormones, a term derived from the Greek, meaning to *excite* or *arouse*. They are chemical substances, each with a particular function within the body. The hormones influence growth, nutritional processes, and other specific physiological activities. Thyroxin is the hormone secreted by the thyroid gland.

etabolism of iodine

Absorption. Iodine is readily absorbed. Within 3 to 6 minutes ter the administration of radioactive iodine to individuals in the sting state, it has been detected in the hand using the Geiger-Muller unter (7). Students in chemistry do a simple test to measure the eed of absorption. A capsule of (0.2 gm) potassium iodide is allowed and in a few minutes the saliva gives a blue color with rch paste, indicating the presence of iodine.

Most of the iodine is absorbed from the small intestine. Some, owever, enters the blood stream directly from the stomach. It can en be absorbed from the skin but not to an extent to be of practical portance.

Fate in the body. After absorption into the blood, the iodine is ken up by the thyroid gland and other tissues. The thyroid gland ncentrates the element and serves as a storehouse for it. In man the tio of iodine in the thyroid to that in the blood is around 25 : 1.

After the iodine is concentrated, in the normal gland it is formed to three iodine containing compounds, thyroxine, monoiodotyrosine, d triiodothyronine. These three compounds are present in the and in a complex known as thyroglobulin. Of these compounds, yroxine is the one that leaves the gland to enter the blood stream d carry on the functions of the hormone throughout the body.

The body is conservative of its iodine supply. When thyroxine eaks down, as it does in the normal process of body function, it is lieved that some of the iodine is saved for reuse. The salvaged dine joins that absorbed from the gastrointestinal tract in a common ol for use.

Excretion. The chief pathway of excretion of iodine is by way of e kidney, with lesser amounts through the intestine, and in perspira- n. During lactation some is secreted into the milk. During the ying season some of the iodine fed to hens is recovered in the eggs.

nctions of iodine

So far as is known, the only function of iodine in the body is that f serving as an essential component of thyroxine and the other iodine- ntaining compounds of the thyroid gland. Consequently, the phys- logical functions of thyroxine are those of iodine also.

Thyroxine was first isolated from the thyroid gland by Kendall at e Mayo Foundation, Rochester, Minnesota, in 1915. Not until even years later was it produced synthetically. Harington and arger of England accomplished the fete.



Fig. 42. A child suffering from cretinism. (Courtesy Scrimshaw, Institute Nutrition of Central America and Panama, Guatemala, C.A.)

In energy metabolism. The primary function of the thyroid h mone is that of influence on the rate of oxidation in the cells of body. An increased secretion of thyroxine speeds up the rate energy metabolism, a lack of it retards the rate. Consequently, basal metabolic rate, which is an index of the rate of oxidation in cells, is also an indicator of the normality of thyroid function. elevated basal rate is associated with hypersecretion of the hormo a low rate with hyposecretion.

In growth and development. Thyroxine is essential for the nor growth and development of the young of all species. With an und secretion growth may be retarded, and if the reduction is severe

d, will result in failure to mature both physically and men-

n suffering from a severe deficiency of the thyroid secretion
n as cretins. Their growth is retarded and their develop-
ested; their facial features appear coarse and swollen; the skin
dry, and pasty in appearance, and often deeply wrinkled.
gue is enlarged, the lips are thickened and usually rest ajar
). Cretinism occurs today in those parts of the world where
ortage still exists.

gnancy and lactation. Iodine is essential for normal repro-
in both man and animal. Observations made in low-iodine



A young woman showing endemic goiter. (Courtesy Scrimshaw, Insti-
utrition of Central America and Panama, Guatemala, C.A.)



The Goitre Areas of the World

ive evidence of this need. A prolonged and severe lack may
a sterility, or if young are born, they may be deformed. Farm
in low-iodine regions showed abnormalities in reproduction
e now prevented by providing sufficient of the mineral. Pigs
orn without hair; sheep, swine, horses, and cattle developed en-
thyroid glands during pregnancy, and the mortality rates were
nong the young.)

c goiter—the result of an inadequate intake of iodine

er is a term applied to an enlargement of the thyroid gland.
enlargement is due to a deficiency of iodine, it is "endemic"
so named because the condition is common to certain geo-
regions. These areas are characterized by a low iodine con-
the soil. It is also known as "simple" goiter. In iodine defi-
the thyroxine level in the blood is lower than normal, which
tes the thyroid gland to greater action, tending to cause it to
. A young woman with endemic goiter is shown in Fig. 43.

graphic incidence. From early time to the present era, endemic
has been notably prevalent in some geographic areas, uncom-
others. The highest incidence has been observed in the Alps,
renees, the Himalayas, the Thames Valley in England, certain
of New Zealand, a number of South American countries, and
eat Lakes and Pacific Northwest regions of the United States.
44 shows the goitrous sections of the world.

affected areas of the United States became known from the
of the physical examinations of the troops of the First World
It was evident that the young men afflicted with endemic
came predominantly from certain regions of the country. The
ordering on the Great Lakes and those in the Pacific North-
d the highest incidences (Fig. 45). Subsequent surveys among
children in these areas confirmed them to be goitrous regions.

any parts of the world goiter does exist today, and to such an
that it is a major health problem (*10*). It is sufficient to say
hat it is no longer a serious problem in the United States; our
will be discussed subsequently. Scrimshaw of the World
Organization (*11*) believes, furthermore, that all of the goi-
reas in the world have not been identified as yet and will not
specific surveys are done. He pointed out, for instance, that
er of the Latin American countries did not recognize that they
erious goiter problem until widespread physical examinations
ents of the populace were accomplished. The surveys made



Fig. 45. Goitrous areas in the United States and Canada. (Courtesy McClen *Iodine and Incidence of Goiter.* The University of Minnesota Press, Mi apolis, p. 126, 1939.)

between 1950 and 1956 disclosed an incidence of endemic goiter high as 50 per cent or more among the school children in some are

Age and sex incidence. Women and girls are afflicted with demic goiter more commonly than men and boys. Adolescence the period of greatest susceptibility to limited iodine intake. B develop thyroid enlargement at this age but to a lesser extent t the girls. The incidence of endemic goiter among Costa Rican sch children illustrates the higher occurrence among adolescent girls, per cent of whom were afflicted, in contrast to 19.4 per cent of boys.

Historical incidence. As early as the first century A.D. ende goiter was described among people living in the Alps. Burnt spo was used as a treatment for the disorder in 1280, but it was more t 5 centuries later, in 1819, that the effective substance in the spo was discovered to be iodine. Following this discovery the elem was used therapeutically and prophylactically for endemic goi Varying degrees of success were realized from its use because of l of knowledge of the amounts needed. Continued experimenta and additional clinical experience gave evidence that prophylactic ministration of iodine to man reduced remarkably the incidence endemic goiter.

use of iodine as a preventive measure. Although the use of prophylactically was attempted in man as early as 1820, the ness was not convincingly demonstrated until the experiments ublic schools of Akron, Ohio, in 1917. Adolescent girls were for study because of the high incidence of thyroid enlarge- that age-sex group. Two grams of sodium iodide was ad- ed twice yearly to 2190 girls during the $2\frac{1}{2}$ years of observa- A group of 2305 with no additions of iodide was followed as s. Among those taking iodine only 5 developed thyroid en- ent as contrasted to 495 in the control group.

922 the state of Michigan, through the Medical Society and Department of Health, surveyed the state for incidence of goiter school children. An average incidence of 47.2 per cent indi- n urgent need for prophylaxis. Through the cooperation of holesale Grocers' Association and the Salt Manufacturers' Asso- table salt containing potassium iodide was put on the market. ioneering attempt to provide iodine for the people of Michigan companied by an educational program emphasizing the need for ment in the diet.

most recent resurvey of school children in Michigan, to assess ectiveness of iodized salt as a prophylactic measure was in 1952, rs after its introduction. In 4 counties 53,785 children were ed. The incidence of endemic goiter had fallen from 47.2 t to 1.4 per cent in that period (*3*). In 1954 the Department lth in Ohio resurveyed the school children in 4 counties that irst examined in 1925. The incidence among the boys in an study was 24.2 per cent; in 1954, 2.2 per cent. Among the e incidence was 40.5 per cent in 1925, and was reduced to 5.8 t in 1954 (*8*).

use of iodized salt is believed to be the major influence in the of endemic goiter in the United States. The importance of particularly for persons living in goitrous areas, cannot be phasized. Another factor contributing to the decrease in the ce of iodine deficiency is a marketing system that brings to ality a food supply that originates from diverse areas of the . As a consequence, some foods grown in non-goitrous sec- pear in the diets of persons living in the goitrous areas.

ccasion, rumors circulate that the use of iodized salt is harmful th because of the iodine content. The World Health Organ- Study Group on Endemic Goiter, whose opinion indeed com- respect, states this: "In no country in which iodine prophylaxis n used on a community scale, has this measure had any adverse

effects on the health of the population." From the report
Third Conference on Nutrition Problems in Latin America, th
ment concerning the prophylactic use of iodine explains furt
" . . . all reports of unfavorable effects which have been inve
have proved to be false or explainable on the basis of conc
(*11*).

Recommended Allowances

Requirement for iodine in quantitative terms has not bee
established chiefly because satisfactory methods for determin
need are not available at present. Indications of the amount r
have been arrived at by balance studies. The minute quant
iodine in foods and excretions have made such studies difficult
form and have contributed to the variability in results. Ba
urinary and fecal excretions, the need is estimated to be betwee
and 0.004 mg daily per kg for normal adults. It is particular
portant that the intake be adequate during adolescence and preg

Influence of goitrogenic agents in foods on iodine needs. It
seems to be little doubt but that there are factors in some foo
increase the need for dietary iodine (*6*). They are called "
genic" because they increase susceptibility to goiter resulting
iodine deficiency. It is believed that these substances may
sponsible, at least in part, for the simple goiters that appear i
man and animal at times, in spite of intake of iodine that
normally be considered adequate.

The discovery that goitrogenic factors exist came from experi
studies with animals. It was in 1928 at Johns Hopkins Uni
that rabbits fed on fresh cabbage almost exclusively were obse
develop enlarged thyroid glands (*4*). It was a fortuitous findi
the investigators were actually seeking information on a certa
ease condition unrelated to goiter.

Since that early study with cabbage, other foods, including
flower, broccoli, Brussels sprouts, mustard, turnips, and ru
have been found to have a goitrogenic effect in both man and
It is unlikely, however, that they will have any untoward ef
these foods are eaten in normal quantities. It is felt that there
be a possibility of increased susceptibility to goiter, if for some
the dietary intake were limited almost entirely to vegetables
content of the goitrogenic factor. It is fortunate that cook
moves the goitrogenic property of the vegetables.

The chemical structure of some of the goitrogenic facto
been established. A substance in white turnips and kale ha

d as the chemical compound, L-5-vinyl-thiooxalidone. It in-
ic uptake of iodine by the thyroid gland in both man and ani-
. From India has come the announcement of the isolation of
genic compound in ground nuts, a product used in large
in human diets in parts of India. Ground nuts have long
spected of being goitrogenic; now a chemical compound,
oside, isolated from the food is found to increase the incidence
r in rats (*9*).

able 21. Average Iodine Content of Some Common Foods

	Iodine content, mcg/kg	
	Fresh	Dry
d milk products		
cow's	35	
e	51	
	56	
	93	
d Meat Products		
on	27	
	28	
	45	
	77	
	97	
ne Fish		
dines	284	745
ckerel	371	1031
libut	520	2225
Perch	742	3105
d	1463	7493
ddock	3180	15941
romous		
Trout	320	1028
mon	341	1030
Water Fish		
rp	17	68
ke Trout	31	88
ver Perch	40	194
Oil		
lmon Oil	2450	
d liver oil	8387	
Shell Fish		
Crab	308	1292
Oyster	577	4712
Lobster	1020	4744
Shrimp	1300	4987
Cereal Grains & Products		
Rice	22	39
Maize	27	43
Wheat	37	44
Vegetables		
Lettuce	26	668
Carrots	38	202
Asparagus	42	1102
Potatoes	45	197
Cabbage	52	260
Spinach	201	1636
Legumes		
Peas	23	223
Beans	36	245
Fruits		
Pears	10	62
Tomatoes	17	196
Apples	16	277
Cranberries	29	100

Iodine Content of Foods, Iodine Educational Bureau, London, 1952.

Food sources

The amount of iodine in most foods is exceedingly small, re sensitive chemical methods to determine it quantitatively. Th tent varies widely among foods, and even for the same food different soil and fertilizer conditions. Average values for some mon foods are presented in Table 21. Often the value was d from widely divergent composition figures. The values are here for comparison of the relative iodine content of various groups rather than the quantitative estimate of the iodine cont diets.

Marine or deep sea fish and shell fish are high in iodine co The anadromous group of fish (spend a part of the time in sea and a part in fresh), to which salmon and sea trout belong, c *more* iodine than do the fish that remain all of the time in fresh and *less* than most of the fish that remain at sea. Fruits and tables provide small and variable amounts of iodine. The extr wide differences is illustrated by the values for carrots and l summarized in Table 22.

Table 22. Variation in Iodine Content of Foods

	Number samples	Iodine Content mcg/kg on dry basis Range	Average
Carrots			
Florida	3	108–356	240
Oklahoma	3	324–531	407
Louisiana	4	1039–1620	1283
Lettuce			
Georgia	2	298–428	363
Oklahoma	8	248–1557	543

From *Iodine Content of Foods*, Chilean Iodine Educational Bureau, London

A supplement to the iodine intake in goitrous regions bec essential. Iodized salt is an effective means of providing the su ment. The amount of iodine added to salt in the United Sta 0.01 per cent of iodine in the form of potassium iodide. It i compulsory by law that iodine be added to salt, but is volun added by the manufacturers. A recent nationwide survey rev that 20 per cent of the families never use iodized salt, 4 per cen it a part of the time, and 76 per cent use it exclusively (5).

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APTER 11

The other mineral elements

his time, it is known that animals and man require fourteen
nt mineral elements for good health and growth. Certain ones,
, phosphorus, sodium, chlorine, potassium, magnesium, and
are needed in appreciable amounts; others, iron, manganese,
, iodine, zinc, cobalt, and molybdenum, are needed only in
nall amounts or traces. This latter group, therefore, has come
referred to as the "trace elements." Furthermore, traces of
elements such as aluminum, boron, fluorine, vanadium, and
have been found in animal tissues but as yet there is not con-
evidence that any of these has a specific biological function.
um, chlorine, potassium, magnesium, sulfur, manganese, copper,
obalt, and molybdenum are discussed in the sections of the
. Calcium, phosphorus, iron, and iodine have been discussed
oter 10. Although fluorine has not as yet been classified as an
l mineral, it is discussed here because of the relationship be-
fluoridated drinking water and the reduction of dental caries
.

Sodium and Chlorine

ems appropriate to discuss sodium and chlorine together inas-
s they are closely related in both function and dietary intake.
an average diet, man ingests about 4 to 5 gm of sodium each
Man's daily intake of chlorine from food, however, is somewhat
about 6 or 7 gm per day. Most of the chlorine in the body is
in the form of chloride ions. Although most of the sodium is

found in the blood plasma and in the fluids outside the cells (ex
cellular), recent findings indicate that some of the body sodiu
found in the bones. As yet, the nature of bone sodium is not
understood but it appears to be important as a store of the ele
for emergency use. Chlorine, as chloride, like sodium, is fo
largely in the blood plasma and the fluids outside the cells of the bo
In the foods we eat and in the body, some of the sodium and chlo
are combined to form sodium chloride, ordinary table salt.

Functions of sodium and chlorine

Sodium and chlorine as major constituents in the extracellular fl
contribute to the osmotic pressure through their inability to m
freely across cellular membranes. They help also in the regulation
acid-base balance; sodium together with calcium, magnesium, a
potassium in the extracellular fluid are basic in reaction; chloride w
phosphate and sulfate groups, and protein are acidic in reaction.
addition chlorine is found in gastric juice as a component of
hydrochloric acid molecule; and in salivary amylase the chloride
activates the starch-splitting enzyme of saliva.

The effects of a sodium and chlorine deficiency

There are numerous studies that have shown the effects of sodi
deficiencies in the animal organism, yet there are few available wh
deal solely with a chlorine deficiency. Much of the data report
however, demonstrates the combined effect of a sodium chloride
ficiency.

A deficiency of sodium in the ration of rats produces retard
growth, perhaps related to the depressed appetite observed to acco
pany the deficiency (*15*). The effects of sodium inadequacies in
human have also been reported. A premature infant, ingesting a lo
sodium feeding for a period of 49 days, lost weight throughout
seven weeks even though the energy intake was adequate (*4*).

A deficiency of chlorine in the ration of the rat also produces
tarded growth but to a lesser degree than has been shown with eit
a sodium or a combined sodium chloride deficiency. Slow grow
in rats fed a chlorine-free ration for a period of three months has b
reported by workers at Johns Hopkins University.

There are evidences of the effects of low as well as high intakes
sodium chloride in both animals and man. Rats fed rations defici
in sodium chloride grew more slowly, lost hair about the back a
shoulders, and showed signs of internal hemorrhages in the thy

d the liver. Moreover, slower growth rates have been ob-
n rats fed either a low or a high intake of sodium chloride.
with healthy men (*11*, *12*) indicate that sodium chloride has
rtant influence on the capillary activity and on the consump-
oxygen of the body. After 14 days on a rich sodium chloride
subject showed an increased blood pressure and an increase
asal metabolic rate, and a coarsening and thickening of the
walls of the fingernails, arm, and skin of the chest. The
ested by this man contained 15 gm salt, 600 gm meat, 100 gm
0 gm cheese, and vitamins supplied by tablets. When this
was shifted to a poor sodium chloride diet, which contained
gm of salt per day, it was noted that all the symptoms de-
above regressed. The average daily consumption of salt in
ed States is approximately 6 gm.

ended Allowances for sodium and chlorine

little is known about the exact requirement for sodium and
. The National Research Council suggests that the normal
ient is more than met for these two minerals from the food
salt added to the food in an average diet. However, the re-
nt is increased when the environmental and climatic conditions
increased sweating. In many industrial companies, employ-
are exposed to excessive heat have at their disposal salt tablets
ime in order to compensate for the sodium chloride lost in
tion.

urces of sodium and chlorine

m is widely distributed in the food inasmuch as the sodium-
ds come from animal sources such as fresh meats, fish, poultry,
d milk. In contrast, foods from plant sources are usually
sodium. Foods like ham, bacon, salted fish, bread, crackers,
ers, have a high sodium content because salt is added during
ng. The theoretical sodium content of salt is 39,342 mg per
or about 2.8 gm per teaspoon.
s food and salt, drinking water may be an important con-
of dietary sodium. For example, the public drinking water
ston, Texas, contains as much as 34 mg of sodium per 100 ml;
Washington, D.C. contains about 0.3 mg per 100 ml. As-
that a man in Washington, where the water sodium is low,
$2\frac{1}{2}$ liters of water each day, he will have an intake of about
f sodium from water alone.

Owing to the abundance of chlorine in the normal diet, it is unlikely that a human deficiency from this mineral will occur. Pork, beef, eggs, certain cheeses, and clams are very rich sources of chlorine, whereas fruits and vegetables contain only small amounts of this nutrient. Olives, crackers, ham, bacon, butter, and other similar foods contribute chlorine because of the salt added during processing. The theoretical chlorine content of salt is 60,300 mg per 100 gm or about 4.2 gm per teaspoon.

Potassium

The adult human body contains about two and one-half times as much potassium (about $\frac{1}{2}$ lb) as it does sodium ($\frac{1}{5}$ lb), yet the normal daily intake of potassium is even a little less than the intake of sodium (3 to 4 gm for potassium, 4 to 5 gm for sodium). It is obvious that the body is more conservative of its potassium than of sodium. Potassium is concentrated primarily within the cells rather than in the extracellular or interstitial fluids as is sodium. Concentration of potassium within the cells contributes to the capacity of the body to conserve the mineral.

Function of potassium

Like sodium and chlorine, potassium functions in the maintenance of the osmotic pressure and the acid-base balance of the body—sodium and chlorine functioning almost wholly in the extracellular fluid, potassium within the cell in the intracellular fluid. Recent findings suggest that potassium may be important in the use of amino acids following protein depletion as well as in optimal bone calcification.

The effects of a potassium deficiency

The effects of inadequate potassium differ from species to species. Rats deprived of adequate potassium in their rations show slow but steady growth after eight and one-half months on low potassium intakes. Sexual maturity of these animals was delayed, and the hair was thin and rough. The symptoms of a potassium deficiency in chicks are retarded growth, followed by loss of the use of the legs and finally death (Fig. 46). Like the chick, the dog fails to grow and develops paralysis when fed inadequate amounts of dietary potassium.

It is quite unlikely that a potassium deficiency occurs in man under normal conditions of health, but cases of hypopotassemia (potassium deficiency) have been reported in conditions of disease and starvation



The effects of a potassium deficiency in chicks. (Courtesy of Gillis, *ion* **36**: 351, 1948.)

rge city hospital, during a period of one year, 309 of the sur-tients treated were found to have suboptimal serum potassium nd showed symptoms of hypopotassemia, muscular weakness, nargy (*18*). These symptoms were relieved by intravenous s of a solution containing potassium. In three cases of human on (*26*) the symptoms involved central nervous system damage disappeared when potassium salts and vitamins were admin-. The body's restoration of potassium within the cells, how-as very slow in spite of the fact that large amounts of potas-nloride and a potassium-rich diet were ingested by the three .

ended Allowances and food sources of potassium

human requirement for potassium is not known; it is likely that despread distribution in plants and animals safeguards an ade-take.

sium is found in almost all foods, both plant and animal, but in very small amounts in drinking water. Foods which con-re than 1 gm of potassium per 100 gm include dried lentils, ans, soybeans, tea, coffee, cocoa, postum, spices, and bran.

Magnesium

Studies to determine the role of magnesium in the nutrition of mals have lagged behind those of many other mineral elements cause of the lack of a usable radioisotope of magnesium. It is kno however, that magnesium catalyzes many reactions that take plac cells. The adult human body contains about 21 gm of magnes concentrated primarily in the muscles and skeleton.

Function of magnesium

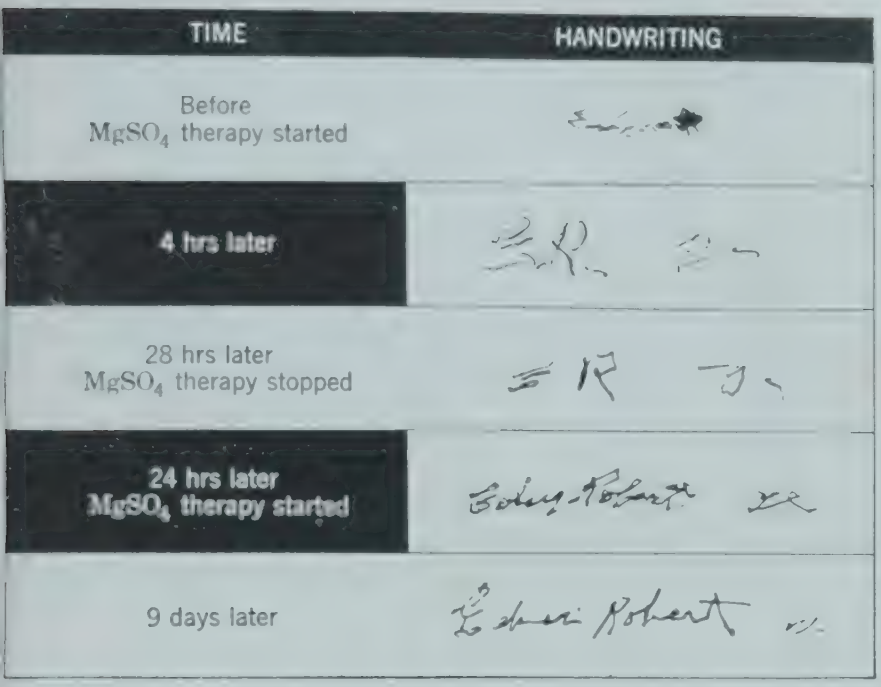
The exact function of magnesium in the animal organism is not clearly understood but it appears to be important in certain enzym reactions and in calcium and phosphorus metabolism. In the me olism of carbohydrates, magnesium activates several of the enz systems that are necessary to break down glycogen in order to rel energy for the body's use. Although the teeth and bones con about 70 per cent of the body's magnesium, little is known about calcium-phosphorus-magnesium relationship within these tissues. times of calcium shortages, magnesium in small amounts appears to place calcium in the body stores to some extent, whereas exces amounts of magnesium in the diet tend to interfere with the nor calcification of body tissue.

The effects of a magnesium deficiency

Experimental magnesium deficiencies have been developed in sev species of animals, including rats, rabbits, calves, and ducks. Sy toms of the deficiency are similar, characterized by retarded grov convulsive attacks, and finally death, if the deficiency is maintai Deficient rats in which a magnesium deficiency has been develo are hyperexcitable; the sound of paper rustling will precipitate a c vulsive attack.

Magnesium deficiencies in man have been identified but as yet well defined. The symptoms of a magnesium deficiency state 6-year-old boy were tremors and muscular twitchings, which in fered with movements such as writing, were relieved with the intake of magnesium sulfate. Magnesium deficiencies in adult pati resulting from chronic alcoholism, complicated by delirium trem have been observed (*13*). The low blood serum magnesium value well as the gross muscular tremors and delirium in these patients w relieved by magnesium therapy. An interesting observation in

Delirium Tremens and Arteriosclerosis Obliterans



Signatures of handwriting, obtained from a patient with low serum ium levels, at various times as indicated. Part of the name has been ob-d. (Courtesy of Flink, *J. Lab. Clin. Med.* **43**: 169, 1954.)

was the improvement of the muscular tremor after the admin-on of magnesium sulfate as shown by samples of handwriting of the patients (Fig. 47).

mended Allowances and food sources of magnesium

National Research Council has made no recommendation for need of magnesium because the amount required is yet un-n. It is assumed, however, that sufficient amounts of the element e available to the body from the ingestion of an ordinary diet. se magnesium is found in so many foods which are common to iet, a deficiency of the mineral is probably caused by poor uti-n rather than by a low intake. Magnesium occurs in meats, s, milk, and other plant foods.

Sulfur

fur is found in every cell of the body, located principally in the -containing amino acids; it is also present in body secretions, and bile, and in the hormone, insulin.

Function of sulfur

It is assumed that this element is related to protein nutrition bec of its occurrence in the sulfur-containing amino acids. The ex function of sulfur in the body, however, has not been fully establi

The effects of a sulfur deficiency

Although little is known about the effects of inadequate sulfur man and animals, studies have been made on the effect of sulfu containing amino acids on wool production in sheep and hair grow in humans. Because wool contains about 13 per cent cystine, one the sulfur-containing amino acids, research has been done to study th influence of this amino acid on the wool production of sheep. Gen erally, the effects of feeding supplementary cystine to improve th wool production have been negative. Also, there is no evidence t warrant a relationship between a dietary deficiency of these amin acids, thus sulfur, and the lack of hair growth in the human.

Recommended Allowances and food sources of sulfur

The National Research Council has not yet suggested a human re quirement for sulfur. Because the mineral is so closely tied to protei nutrition, its requirement by the human is undoubtedly related to th protein requirement. Organic sulfides are found in both plant an animal foods. Wheat germ, lentils, cheese, lean beef, kidney bean peanuts, and clams are exceptionally rich food sources of this minera

Manganese

Manganese is found in the liver, skin, bones, and muscles of animal In fact all animal tissues thus far examined contain some manganese but in very low concentrations. The relative amount of it found i the human body is about 0.2 gm or $\frac{7}{1000}$ of an ounce in an averag sized man.

Function of manganese

As yet, the function of manganese in the animal body is not under stood.

The effects of a manganese deficiency

Metabolism studies with the rat, chick, and rabbit have reveale the effects of a manganese deficiency in these species. The norm processes of reproduction and lactation in the rat are interfered wit when they are fed rations low in manganese. Female rats fail t



A picture of a Rhode Island red chick afflicted with the type of perosis by manganese deficiency. (Courtesy Poultry Husbandry Dept., Cornell ity, Ithaca, New York.)

their young, while in the male rat there is a degeneration of the of the reproductive system. A manganese deficiency in chicks acterized by an abnormality of the leg bones known as *perosis* ped tendon (Fig. 48). Not only do the bones of the legs and undergo other physical and chemical changes, but the ng effect that results prevents the chick from securing food, ath soon follows. It is now known that choline, one of the soluble vitamins, is interrelated with manganese in the pre- of perosis in birds. An impaired leg bone formation has also bserved in manganese deficient rabbits. In the front leg bones, meri are shorter and break more easily because of the low ash t of the tissue. In addition to the leg bone symptoms, the nt rabbits showed less weight gain than did the ones that re- an adequate amount of manganese.

nese toxicity

ganese toxicity has been reported in both animals and man. imal studies of Chornock, Guerrant, and Dutcher (7) showed gh intakes of manganese retarded growth in rats in proportion amount of the mineral present in the ration. In dogs oral ad- ation of large doses of manganese resulted in gastric disturb-



Fig. 49. The effects of manganese poisoning in Moroccan miners. The pati cannot walk without help. (From collection of Rodier. Courtesy of the auth and *Brit. J. Ind. Med.* **12,** Jan. 1955.)

ances but did not affect growth. Although cases of manganes poisoning are not common in man, toxicity was recognized as ear as 1837 among men who worked loading ores rich in this miner Some of the symptoms of manganese poisoning found in these m were a peculiar mask-like expression of the face, involuntary laughin a low voice with blurred speech, walking with a spastic gait, a tremors of the hands. A recent study (*23*) concerning 150 cases manganese poisoning in Moroccan miners described the same sym toms (Fig. 49).

Recommended Allowances and food sources of manganese

Man's requirement for manganese is not yet known. The avera diet contains about 4 mg of manganese per day, which seems to adequate.

The manganese content of commonly used foods has been mea ured. Studies of the manganese content of one-hundred-twenty d ferent foods has shown that wheat bran, blueberries, whole whe

s, beets, and navy beans are the richest sources of the mineral

Copper

importance of copper in nutrition was first demonstrated
t and others at the University of Wisconsin in a series of
that began in 1925. When rats and rabbits were fed a milk
anemia developed that iron supplementation did not correct
relieved only when the copper-containing ash of certain foods
to the animals. This work established the necessity of cop-
ng with iron, in the formation of hemoglobin in the body.

and effects of a deficiency of copper

is date, the exact function of copper in animals and man is not
ood. However, symptoms that develop in copper-deficient
suggest certain functions. It is involved in the formation of
d cells as a catalyst to the formation of hemoglobin. Copper
part of the hemoglobin molecule, even though essential for its
n. A diet deficient in copper is accompanied by a reduction
oxidative enzymes, cytochrome oxidase and catalase in some
On diets deficient in copper, lambs were found to manifest
in muscular coordination. Autopsy revealed demyelination
l of outer tissue, myelin sheath) of nerve fibers. Dogs show
ing disorder of the bones (Fig. 50). Another manifestation



A bone disorder associated with a copper deficiency in dogs. (Cour-
axter and Van Wyk, *Bull. of the Johns Hopkins Hospital* **93**: 1, 1953.)

of copper deficiency is the greying of hair in several species, the ra rabbit, cat, dog, goat, and sheep.

A copper deficiency in humans has only recently been observe Although in the past a combined deficiency of copper and iron children had been recognized, it was not until 1956 that a group scientists at the University of Southern California demonstrated th use of copper sulfate in relieving an anemic condition in five you children (25). The need for copper in man apparently is most sig nificant in the early months of life because low copper blood leve are a characteristic pattern at birth. However, adult man does no develop a copper deficiency even during long periods of malnutritio This fact has been substantiated by the observations made on thirty eight American prisoners of the Second World War who had receive a very inadequate food intake for an average period of $3\frac{1}{3}$ years (6

Recommended Allowances for copper

Balance studies have been carried out on children and adults t determine the dietary copper needs of the human. In view of thes reports, the recommended daily dietary allowances of the Nation Research Council suggest that adults need about 1 to 2 mg of copp per day, and 0.05 mg per kilogram of body weight is the amou suggested during the period of growth.

Food sources of copper

The copper content of foods varies, but even a mediocre diet wi supply a sufficient amount of the nutrient. From a list of commonl used foods, calves' liver, oysters, beef liver, mushrooms, currants, an chocolate are found to be the richest sources of copper.

Zinc

Little is known concerning the role of zinc in the nutrition o animals. Although small amounts of the mineral are found in th cells of the liver and spleen of animals, zinc has been found to be in dispensable to only two species of animals, the rat and the mouse.

Function of zinc

Even though the exact function of zinc in the animal body is un known, it has been shown to be a component of two important en zymes of the body as well as a part of the hormone, insulin. Th enzyme, carbonic anhydrase, which is found in the red blood cel where it speeds the breakdown of carbonic acid in the lungs durin

change of carbon dioxide for oxygen, contains zinc. The l is also an essential part of one of the protein-splitting enzymes d by the pancreas. The presence of zinc in the chemical re of insulin, however, has been known since 1934. Although types of insulin have been developed throughout the years, the hich has been most widely used is protamine-zinc insulin. This which is more slowly absorbed from the tissues than is plain . requires less frequent injections to maintain the diabetic t. It appears that the addition of zinc to the insulin solution retarding effect and therefore prolongs the activity of the ne in the body.

fects of a zinc deficiency

y two species of animals have shown a requirement for zinc. suboptimal amounts of zinc are fed in the ration of rats, the s grow at a slower rate and lose hair about the neck and ers. The same symptoms of slow growth and alopecia occur e fed rations deficient in zinc.

mended Allowances for zinc

zinc requirement of man is unknown but the results of balance s have shown that there is a retention of the mineral in the From the difficulties experienced by research workers in pre- a zinc-deficient diet, it might be concluded that the possibility s deficiency occurring in animals and man is very unlikely be- most natural diets appear to contain an amount of the mineral ent to maintain good health.

sources of zinc

is found in most of the foods eaten in a normal diet. Al- h the richest food sources are oysters, wheat germ, and bran, iver, gelatin, and dried eggs are good contributors also. Fruits egetables, however, contain only very small amounts of the al.

Cobalt

alt is one of the most recent mineral elements to be recognized ential for the animal organism. It is needed in very small nts and has been shown to be part of the vitamin B_{12} molecule.

on of cobalt

rectly, cobalt functions in the formation of red blood cells be- of its important part in the vitamin B_{12} molecule. Recent



Fig. 51. The (top) picture shows a Guernsey calf affected by cobalt deficiency. After it was fed cobalt for a few weeks, the calf looked like this (below). (Courtesy Keener, from Sta. Bull 411, Agriculture Experimental Station, University of New Hampshire.)

tions with cattle and sheep have established the way that co- pparently functions in the animal organism. These animals, t only plant foods which contain little or no vitamin B_{12}, need for the manufacture of the vitamin in their stomachs or rumen. intake of cobalt is low, then a suboptimal amount of the vita- ll be available and a deficiency will result.

ects of a cobalt deficiency

Zew Zealand and Australia cattle and sheep have long suffered wasting disease that is now known to be caused by a defi- of cobalt in the soils and as a consequence in the pastures which they graze. Animals ingesting these low-cobalt grains rasses showed symptoms of listlessness, loss of appetite and , anemia, and finally death (Fig. 51).

mpts to produce cobalt deficiencies in rats, guinea pigs, and have been unsuccessful. However, the addition of cobalt to tions of rats and chicks has produced a growth-stimulating n both species.

toxicity

obalt is fed to animals and man in amounts greater than their ement, an increase in the number of red blood cells results. sorder is referred to as *polycythemia*. This condition has been ed in rats, mice, guinea pigs, rabbits, dogs, pigs, chickens, frogs, an. Experimental polycythemia has been observed in normal hen fed daily intakes of 150 mg of cobalt salts (*9*). After ng the cobalt salts for a period of 7 to 22 days, the subjects d increases in the number of red blood cells ranging from 16 to cent.

mended Allowances and food sources of cobalt

daily need for cobalt has not been established but is probably small. Although there is little data on the cobalt content of it appears that the average diet more than supplies adequate ts of the mineral to match the needs of man.

Molybdenum

n though the toxic effects of molybdenum in animals have nown for some time, the importance of the mineral in the nu- of animals was only established in 1953.

Function of molybdenum

Molybdenum has been demonstrated to be an essential factor the rat and dog in the formation and maintenance of an inte enzyme called *xanthine oxidase*. However, no information is ava ble yet on the function, if any, of molybdenum in man.

Molybdenum toxicity

Even though the effects of inadequate molybdenum have not b observed in either animals or man, the effect of excess amounts h been reported in the rat, rabbit, and calf. Rats fed overabund amounts of molybdenum show reduced growth rates and will di the molybdenum content of the diet is too high. Symptoms of tarded growth, loss of weight, low hemoglobin and red blood counts, alopecia, and malformed leg bones have been reported rabbits fed toxic levels of molybdenum (Fig. 52). Chronic moly denum poisoning in calves results in weight loss and changes in hair coat. At first the hair is rough and thin, but as the toxic continues the hair loses its pigment and greys.



Fig. 52. The characteristic malformation of the legs of a rabbit fed a diet to in molybdenum. (Courtesy of Davis, Agriculture Experimental Station, Univ sity of Florida.)

ended Allowances and food sources of molybdenum

et nothing is established about man's requirement for molyb- . Like the other minerals discussed in this chapter molyb- too, is widely distributed in commonly used foods. How- gumes, cereal grains, some dark green vegetables, liver, and are good sources of the mineral.

Fluorine

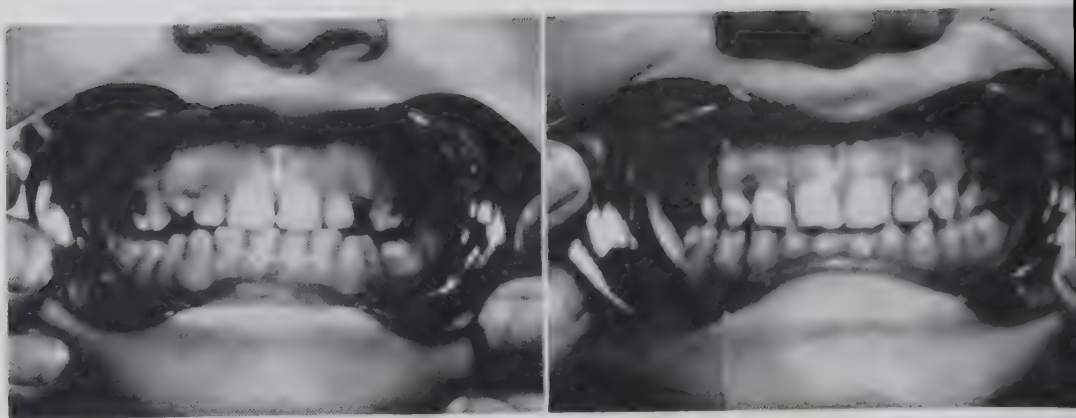
nuch as fluorine has been shown to be valuable in combating ecay in children when ingested in very small amounts, it has prominence in nutrition even though at this time it cannot idered an essential nutrient.

and dental health

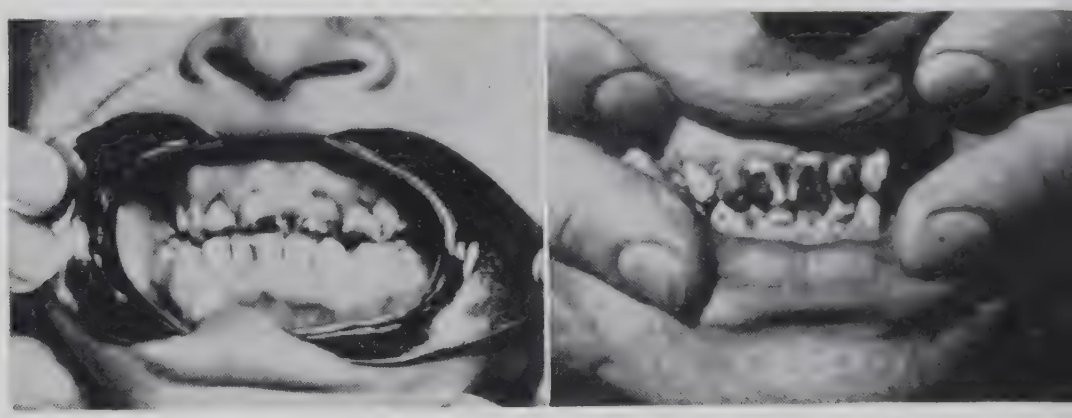
relationship between fluorine and tooth physiology was recog- irst as a public health hazard. In certain areas of the world this country, it was noted that the enamel of human teeth *ttled*. These teeth were dull and chalky in appearance, some evidences of pitting and corrosion, and in severe cases the ere stained a color ranging from yellow to black (Fig. 53). 1 two research groups reported that mottled tooth enamel ic endemic fluorosis) was associated with an excessive amount rine ingested in the drinking water. Soon after this finding, analysis of public water supplies in many areas of the United egan. It became evident then that this dental fluorosis could vented by avoiding waters containing excessive amounts of s or by removing the toxic amounts of the mineral by chemi- ns. It was found, however, that water containing as little as 1 r million (ppm) of a fluoride caused little or no mottling of the Dean (*10*), however, was among the first to relate the inci- of very mild fluorosis to a low rate of dental caries in children. r to determine the extent of dental caries inhibition in a popu- y adding a fluoride to the drinking water in amounts of 1 ppm, led studies of water fluoridation were begun between 1944 and Before this time, all the evidence of the role of fluorine in health was based on the findings of individuals born and main- continually in a natural fluoride area.

led fluoridation studies

story of fluoridation can well be divided into three phases (*3*). st, or the period of discovery, constitutes all the early work



(*a*) Very Mild Dental Fluorosis (*b*) Mild Dental Fluorosis



(*c*) Moderate Dental Fluorosis (*d*) Severe Dental Fluorosis

Fig. 53. Pictures showing varying degrees of dental fluorosis. (*a*) Very mil dental fluorosis, (*b*) mild dental fluorosis, (*c*) moderate dental fluorosis, (*d* severe dental fluorosis. (Courtesy of McClure and the National Institute Dent Research, Washington, D.C.)

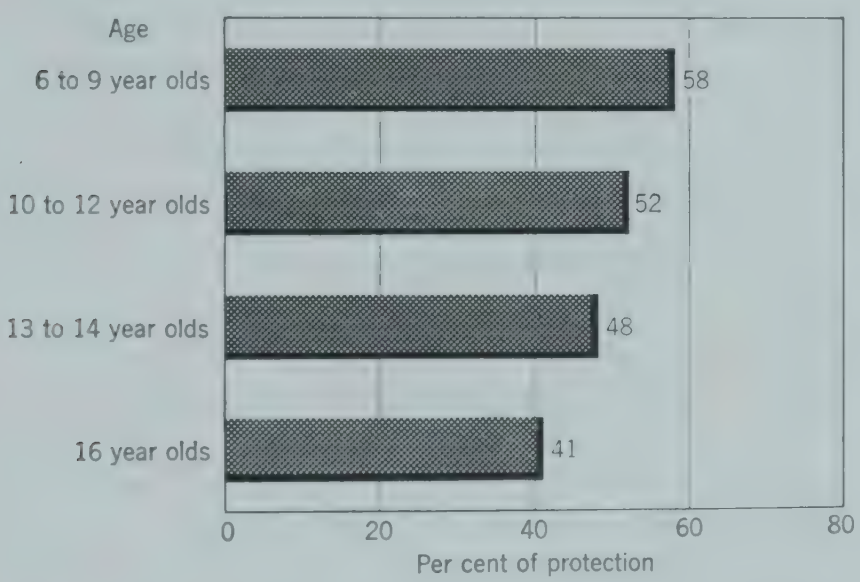
including the announcement of the relationship between very mil dental fluorosis and a low rate of dental decay in children. Durin 1945 the second phase, or the period of controlled experimentation began with the initiation of the two famous fluoridation studies i this country (Newburgh-Kingston, New York, and Grand Rapids Muskegon, Michigan). Since that time, however, other communitie have set up similar fluoridation studies. Although only one, th Newburgh-Kingston Study, will be described here, the results of th tenth year of the Grand Rapids-Muskegon Study (*1*) showed a re duction in caries of the permanent teeth to be about 60 per cent i those children born and reared in Grand Rapids since fluoridatio began. Because the results of these many fluoridation investigation show marked control of dental decay among children, the third phas

f the fluoridation story or the period of development has begun. At the present time there are more than 1100 cities and towns in the nited States using fluoridated drinking water (*21*).

he Newburgh-Kingston study

This 10-year experiment began in May, 1945, in these two New ork communities, located 30 miles apart on the Hudson River. oth cities have the same source of drinking water, inhabitants of milar racial and economic backgrounds, and populations of equal roportions (about 30,000). The water supply of Newburgh, the est city, however, was treated with sodium fluoride so as to contain .0 to 1.2 ppm, while in Kingston, the control city, no fluorine was dded to the water supply. Annual dental examinations and periodic nedical evaluations were made throughout the 10-year period on the elected children from these two communities.

At the end of the 10-year period, the medical and dental data were valuated in order to assess the effects of the intake of fluoridated rater on the incidence of tooth decay among the children of the two ities. The medical officers reported that there was no significant ifference in the height, weight, any of the selected laboratory tests sed, or in x-ray studies of children from the test and control cities *24*). The report of the dental team stated that the clinical and x-ray



ig. 54. The percentage protection against dental caries in the children of New- urgh, as compared with the children of Kingston after 10 years of drinking luoridated water. (Adapted from Ast, Smith, Wachs, and Cantwell, *J. Am. Dental Assoc.* **52**: 314, 1956.)

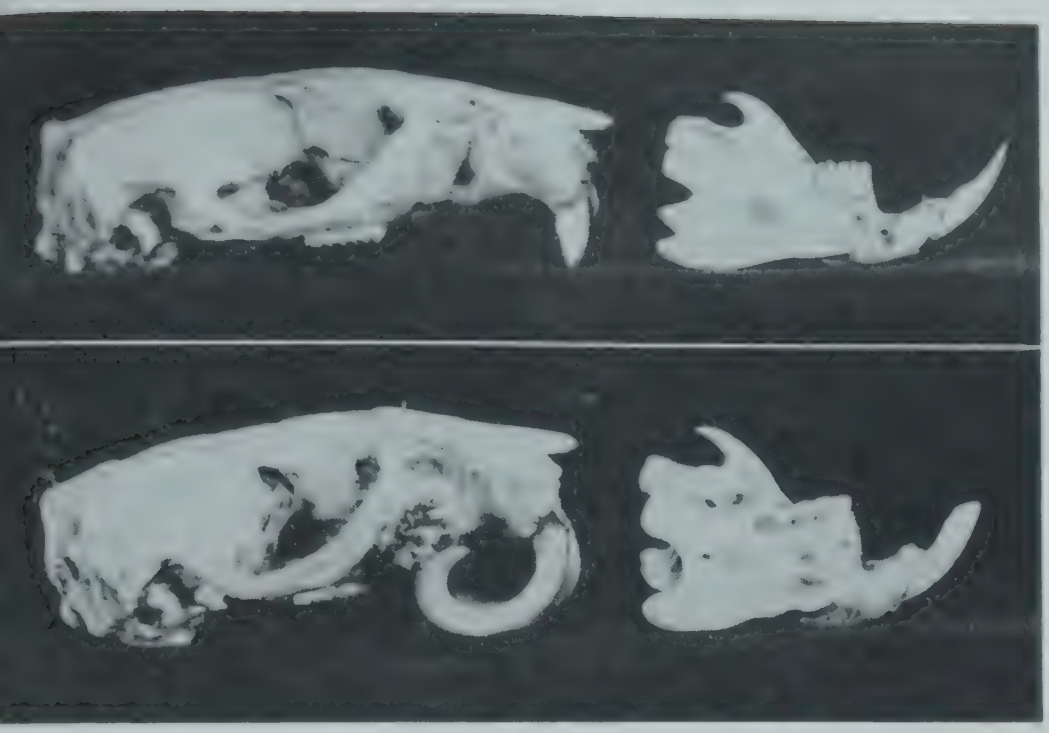
dental examinations of children between the ages of 6 and 16 yea showed that the DMF rate (decayed plus missing plus filled teeth) the permanent teeth was lower among the children from Newburg than from Kingston (*2*) (Fig. 54).

Topical application of fluorides

Approximately one-half of the population of the United States liv in areas where public water supplies are not available, and it is im possible to fluoridate the individual water sources safely of the people. In order that many people of these sections may receive th benefits of fluoridation, topical application procedures of fluorin have been studied and developed. This technique involves the swa bing of the teeth with a fluoride solution at prescribed intervals time. In 1945 it was estimated that about 1150 communities, mostl rural, had adopted a topical fluoride application program (*17*). A though the incidence of dental caries has been reported to have bee reduced by 40 per cent when a 2 per cent solution of sodium fluorid was applied topically to the teeth of large numbers of children (*16* fluorides other than sodium fluoride have been studied in topical ap plication. In a recent report from the Dental School at Indian University (*14*) it was stated that children received greater protectio from topically applied stannous chlorofluoride than from sodiu fluoride. Most of the data available at this time concern children u to 14 years of age. A few isolated studies testing effectiveness topical application of fluorides have been done with adults. Thes data are too few for drawing conclusions. The most likely explana tion for the effectiveness of fluorine in preventing caries is the adsorp tion of minute quantities on the surface of the enamel with the for mation of an acid-resisting protective layer.

Fluorine toxicity in animals and man

Toxic amounts of fluorine or lesser amounts that proved to b toxic after continuous ingestion for a period of time cause drasti changes in the teeth and bones. In the rat, the tooth enamel becom chalky and brittle when excessive amounts of the mineral are fed i the ration. Under normal conditions, the incisor teeth of rats con tinually grow and wear away to provide the animal with a sharp cu ting tooth; too much fluorine in the ration results is an elongate "tusklike" incisor which is no longer useful in securing food (Fig 55). In Fig. 55, the malformation in the bony tissue of the sku which occurs from fluorine poisoning can be seen. In cattle an swine the enamel of the teeth wears away, exposing the pulp cavity



g. 55. Skulls of rats fed on diets with and without fluorine. The top picture ows the normal skull and the bottom one shows the thickened skull with ngated and chalky upper incisors caused by excessive fluorine in the rat. Courtesy Maynard, New York State Agriculture Experimental Station Bull. 530.)

nd it becomes difficult for the animals to ingest food and water wing to the sensitiveness of the teeth.

Balance studies involving the intake of large amounts of fluorine ave been conducted with humans. At intakes of 4 to 5 mg of a uoride per day, it has been shown that almost all of the fluoride in- ested was eliminated (*20*), inasmuch as equilibrium in the body maintained by the loss of the mineral through the kidney and skin. When as much as 12 to 25 mg per day was ingested, almost one- alf of the absorbed amount was stored in the body tissues (*19*). fter the subjects on these high levels of intake were returned to a ormal intake pattern of the mineral, their body stores of fluoride ere slowly depleted. Although the existing information on the ffects of too much fluorine in the human diet is somewhat at vari- nce, it seems very unlikely that there is any appreciable storage of ne mineral in man except in the bones and teeth.

ood sources of fluorine

Fluoride analyses of some typical foods used in the American ietary have been made in nine field stations in the eastern, central,

and western sections of the United States (8). Of all the foods tes only fish and fish products, dry beans, and tea infusion contain more than 1 ppm of fluorine. Milk was very low in the miner (0.09 ppm); most of the fruits, meats, and vegetables contained le than 0.30 ppm of fluorine.

Extra fluorine may be introduced to the diet from fluoride-contai ing insecticides and sprays that are used in fruit and vegetable pe control. In addition to this, vegetables absorb the mineral when the are cooked in fluoride-containing water.

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CHAPTER 12

Water and cellulose

Water is an essential nutrient, yet one that is often overlooke when the nutrient needs of the body are enumerated. Actually, it possible to survive a longer time without food than without wate Water makes up approximately 70 per cent of the body weight; abou 84 lb of a 120 lb individual is water. The necessity of water in main taining life was demonstrated by the German physiologist Rubne who found that during starvation an animal can live if he loses nearl all of his glycogen and fat as well as one-half of his body protein, bu a loss of 20 per cent of his body water results in death.

Approximately two-thirds of the water content of the body is con tained within the cells (intracellular fluid), and the remaining one third is found in spaces outside the cell (extracellular fluid). Th extracellular fluid consists of the fluid between tissues and cells (in terstitial fluid) and the water present in the blood plasma. Betwee 3 to 4 qt of water circulates in the blood stream (*3*).

Functions of water

Water is used in the body in a variety of ways: as a building ma terial, as a solvent, as a lubricant, and as a temperature regulator.

As a building material water is used in the construction of every cell. The cells and tissues of the body, however, vary in their wate content. For example, dentin contains 10 per cent water, fatty tissu 20 per cent, bone 25 per cent, and striated muscle 80 per cent.

As a solvent, water is essential for the normal functioning of the body cells. It is the means by which nutriment is carried to the cell and waste products of metabolism removed. However, before food

n be carried to the cells, it must first be digested. Water is used in gestive processes where it aids in the mastication and softening of od, supplies fluid for the digestive juices, and facilitates the movent of the food mass along the digestive tract. After digestion the trients, in a state of solution or suspension, pass through the intinal wall and are carried to the cells by the blood or lymph. In e cells water is the fluid medium in which the many intracellular emical reactions take place (*2*). After metabolism the blood, which about 92 per cent water, picks up the waste products from the cells d carries them either to the lungs or kidneys for excretion.

As a lubricant water provides an insulation for the joints and inrnal organs. It bathes the body cells, thus keeping them moist and reventing friction.

As a regulator of body temperature, water aids in the removal of at from the body. The evaporation of water on the skin surface an effective way of eliminating generated body heat. It is estiated that the average person excretes about a pint of water daily rough the skin. However, during strenuous physical activity or in hot dry atmosphere the loss of moisture by skin evaporation may be arkedly increased. It has been reported that football players have st from 10 to 12 lb in body weight during a game caused chiefly by loss of water through sweating.

ources of water for the body

The source of water for the body comes from the fluids of the diet, e solid foods of the diet, and the water produced by the metabolism f the energy nutrients within the tissues.

The largest amount of the body water comes from ingested fluids. he average person consumes approximately 1 to 1½ qt of fluid as ater, coffee, tea, soup, and other liquids each day (*2*).

The water content of foods varies widely, with most foods in the erage diet containing more than 70 per cent moisture. Figure 56 ows the percentage of water in some commonly used foods. An teresting comparison to make is that of green beans, a solid food at contains 89 per cent water, and milk, a fluid food with 87 per nt water. The similarity in water content is concealed by a porn of the carbohydrates, one of the constituents contributing to the lids of both foods, being present in green beans in an insoluble rm. The amount of water obtained from solid foods in the diet ay vary from ½ to 1 qt per day, depending on the kind of solid oods consumed.

In the metabolism of the energy nutrients, carbohydrates, fats, and

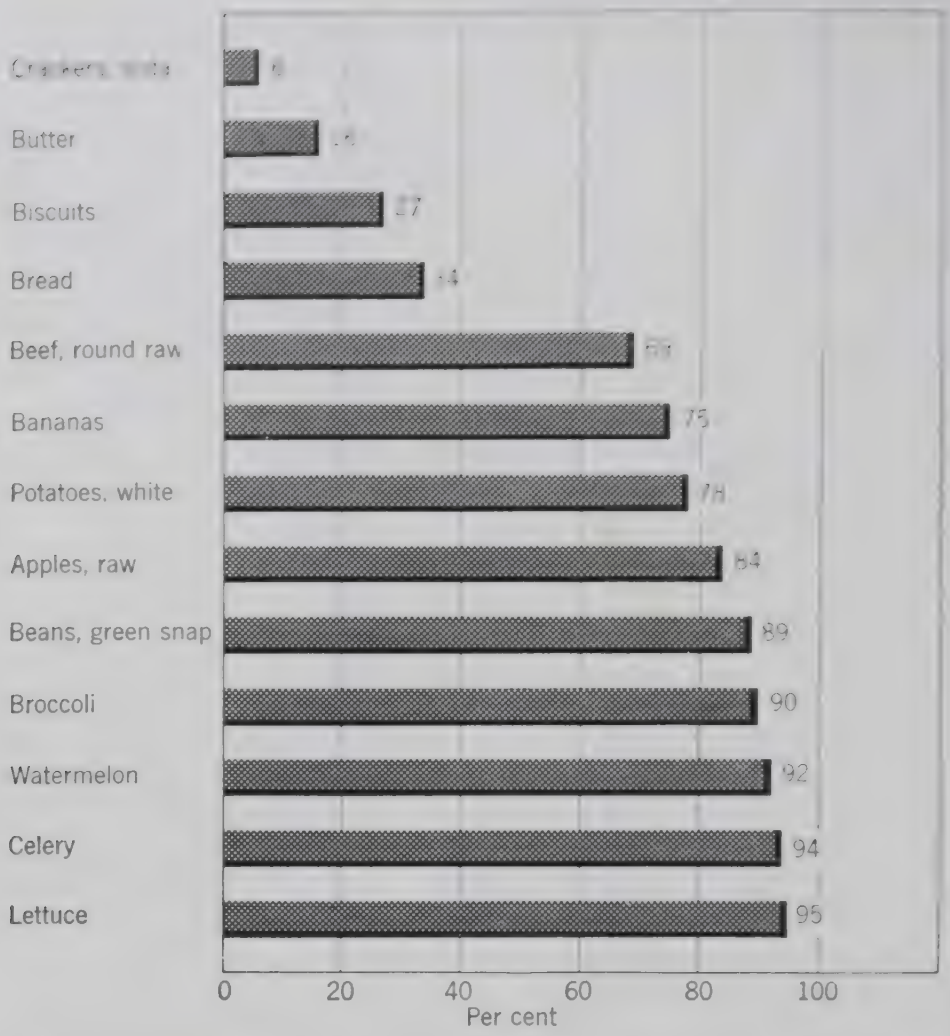


Fig. 56. Percentage of water in some commonly used foods. (From *Composition of Foods—Raw, Processed, Prepared*. Agriculture Handbook 8, U.S. Department of Agriculture, 1950.)

proteins, water is formed. Water obtained from metabolism is a constant source arising from the continuous process of oxidation of food in the body for energy. However, the amount of water produced by the different food substances varies. The estimated amounts are 0.6 gm water per gm of carbohydrate, 1.07 gm water per gm of fat, and 0.41 gm of water per gm of protein (*1*). For example, the water of oxidation produced by the metabolism of a day's dietary might be as follows:

Carbohydrate	275 gm × 0.60	= 165.0 gm of water of oxidation
Fat	90 gm × 1.07	= 96.3 gm of water of oxidation
Protein	75 gm × 0.41	= 30.8 gm of water of oxidation
	Total	292.1 gm

cretion of water from the body

Water is lost from the body by way of the kidneys (urine), skin erspiration), lungs (expired air), intestinal canal (feces), and eyes ars). The amount of water lost by the body is influenced by ter intake, body conditions, and environmental conditions. How- r, the largest amount of water is lost through the kidneys in the ne. The excretion of urine is greatly influenced by fluid intake. e amount excreted by the skin varies according to the need for the dy to lose heat to regulate body temperature. When an individual physically active or the environmental temperature is high, pro- rtionately more water will be lost through the skin than under rmal conditions of activity or temperature. Through the lungs,

Table 23. The Water Balance of an Average Individual

Water intake	Milliliters
Liquid food (water, coffee, milk)	1100
Solid food (moisture)	500–900
Water of metabolism	400
	2000–2400
Water output	
Vaporization (400 ml expired as moist air–lung, and 600 ml skin sweat)	920–1000
Feces	80–100
Urine	1000–1300
	2000–2400

Adapted from Wohl and Goodhart, *Modern Nutrition in Health and Disease*, Lea d Febiger, Philadelphia, p. 368, 1955.

ater is lost as a vapor in the expired air. The relative amount of ater vapor in the expired air can be observed by the amount of oisture condensation formed when an individual breathes on a cold ass object.

An example of the water balance of an individual is given in able 23.

ecommended Allowances for water

The Recommended Allowance (*4*) of water for adults is 2.5 liters 10 glasses daily. In the average dietary a large proportion of this take comes from solid foods. For the young adult, activity and vironmental conditions are the two most important variables which termine the body's need for water. During study, rest, and sleep,

the loss of water from the body is small in comparison to that dur
active exercise such as tennis, basketball, and football. In the su
mer, or when the temperature is high and the humidity low, m
water evaporates from the body surface. In most individuals satis
ing the thirst or the desire for water is the only criteria necessary
meet the body's need. Under conditions of extreme heat where th
is excessive sweating, the thirst mechanism may not allow for t
drinking of sufficient water, making it necessary to supplement t
natural intake. Five or six glasses of fluids should be consum
daily as water or in beverage. The habit of drinking water shou
be encouraged because water is important to normal functioning
the body. Water consumption at meal time is advised if the food
properly masticated, and if water is not used to wash down the fo
Water is thought to aid digestion by promoting the flow of digesti
juices.

Cellulose or Vegetable Fiber

Celluloses, the complex carbohydrates found in the cell walls
plants, are important in the maintenance of the normal peristal

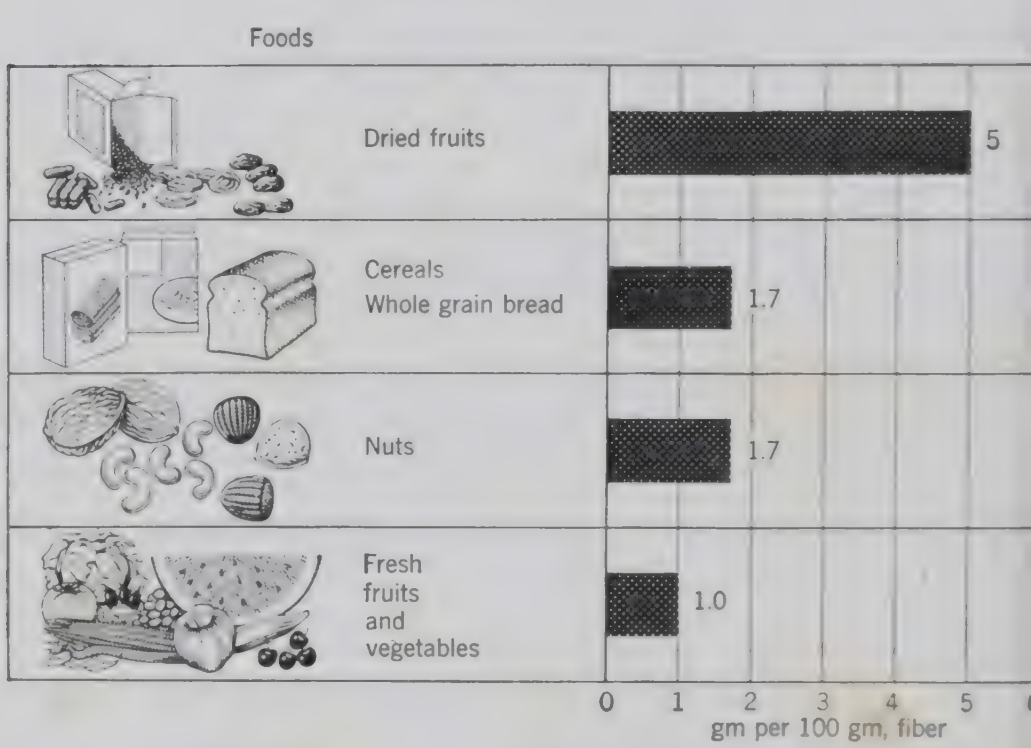


Fig. 57. Average values for fiber content. (Courtesy Rosenthal, Baker, a
McVoy (1949). *Stern Applied Dietetics.* 3rd. ed., Williams and Wilkins C
Baltimore, p. 79.)

ion of the intestines. Because these carbohydrates are practically digestible for man and most animals, they pass through the intestinal act as bulk. However, the species of animals called the *herbivora* attle, sheep, deer, etc.) can derive energy from cellulose because of cterial fermentation in their digestive systems.

nction and sources of fiber

The function of cellulose in the body is to aid in the removal of aste products. Cellulose both absorbs moisture and provides bulk the fecal content thus facilitating the normal evacuation of the ge intestine.

The best food sources of cellulose or fiber are fruits, vegetables, hole grains, and nuts. Milk, meat, eggs, cheese, and highly refined ods are fiber poor. Because the fiber in meat is protein, it is largely gestible, providing little bulk. It has been estimated that 4 to 7 n of fiber are needed daily. This amount can easily be obtained the daily diet includes a serving of whole-grain cereal or bread, servings of vegetables, and 2 servings of fruits. The fiber content a diet can be estimated by using the average figures given in g. 57.

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CHAPTER 13

Introduction to the vitamins: fat-soluble vitamins

The discovery of the vitamins ushered in a new era in nutritio It was one in which *small* things in the diet assumed *great* importanc The percentage of body weight attributable to vitamins is minut Nevertheless, that amount, even though small, is indispensable fo normal functioning.

Early evidence of the existence of vitamins came from the searc for treatments of certain human diseases that persistently plague people. One of these diseases was scurvy. It was one of the hazard explorers and sea voyagers encountered. In the year 1747 relief fro scurvy was enjoyed by a few of the British navy. Freedom fro the illness came about in this way. Limited amounts of lemons an oranges were aboard ship and were given to some of the sailors; th recovery was remarkable. In another part of the world, anothe disease was making the sailors of the Japanese navy ill. This disea was beriberi. The diet of the men consisted mainly of white rice With the addition of vegetables, meat, and fish, a change institute in 1884, the incidence of beriberi decreased.

Despite the improvement in health brought about by changes in th diet, the realization that a lack in the diet was responsible for scurv and beriberi was slow. In fact, it was almost 150 years after th experiment at sea with lemons and oranges before there was accept ance of scurvy as being caused by a nutritional deficiency; and was not until the early 1900's that scientists and physicians accepte beriberi as the result of a deficiency in the diet. That deficiencies i the diet could be responsible for disease was a new concept, whic was adopted with reluctance.

Another avenue of approach to the study of the dietary deficiency cases was the use of animals in the experimental laboratory. In the al analysis, it was the well-controlled laboratory experiments that ntually gave conclusive evidence that certain diseases are caused the lack of dietary nutrients.

In the experimental studies a diet of pure chemical compounds was d, pure protein (such as casein or albumen) pure fat (such as lard), re carbohydrate (such as dextrin), and minerals. The purified diet s really the crux of the experiment, for the natural food more than ely would have provided some of the unknown factors. As it was, ung animals on the purified diet failed to grow; mature animals led to maintain body weight.

McCollum (*1*) in his study of the history of nutrition found Dumas 800–1884) to be the earliest man of science to question the ade- acy of a diet composed only of protein, carbohydrate, fat, and ts. The experience that led Dumas to such a prophetic belief was t with experimental animals, however, but with citizens of France. the time of the siege of France by the Germans (1870–1871) food as scarce; there was no milk for children. Scientists attempted to epare artificial milk using protein, fat, carbohydrates, and salts. he combination was disastrous to the young. It led Dumas to con- ude that there was something lacking in a combination of the then nown nutrients essential for life.

Animal experiments that led up to the discovery of vitamins in- uded those of Pekelharing in 1905 at the University of Utrecht, who ade the important observation that a diet of casein, egg albumen, ce flour, lard, and salts kept his mice alive only four weeks. When added milk to the mixture the mice remained healthy.

Hopkins of England was the most advanced thinker of his time animal nutrition. He said in 1906 that " . . . no animal can live a mixture of proteins, carbohydrates, and fats, and even when the cessary inorganic material is carefully supplied, the animal still nnot flourish." Others of the era were feeding purified diets and pplementing them with natural foods to keep their animals alive. cCollum in 1907, although aware that animals could not survive on rified rations of protein, fat, carbohydrate, and mineral salts, be- ved with many others of his time that the failure to survive was e to the unpalatability of the mixture and the consequent refusal eat a sufficient amount of the ration. He tried to improve the vor by adding sugars and other variations in the ration but the imals still failed to survive. Even though this experiment appeared

to be a failure, it was successful in that it led to his discovery vitamin A a few years later.

McCollum and Davis discovered that there was a substance pre in butterfat or egg-yolk fat that made the difference between model success in the nutrition of young rats on certain diets, and pro failure in its absence. Osborne and Mendel at the Connecticut periment Station found cod liver oil also to contain the essen substance. Thus the first vitamin was discovered and called soluble vitamin A.

There seemed to be only one factor needed to supplement purified diet at the time of the discovery of vitamin A. In a cou of years, however, it was recognized that not one, but two fact were lacking in the purified diet for normal growth, one solu in fat, the other soluble in water. Later of course, numerous n fat-soluble and many additional water-soluble factors were identifi Each is discussed in the chapters that follow. A chronological su mary of the isolation and syntheses of the various vitamins follows

Year	Isolation or identification	Structure or synthesis
1925	Vitamin D by irradiation	
1926	Vitamin B_1	
1928	Inositol	
1931	Vitamin A	
1932	Vitamin C	
1933	Riboflavin	Vitamin C
	Pantothenate	
1935	Biotin	Riboflavin
1936	Anti-egg-white factor	Vitamin D
	Vitamin E	Thiamine
1937		Vitamin A
		α-tocopherol
1938	Nicotinic acid identified as pellagra-preventing	*dl*-α-tocopherol
	Pyridoxine	
1939	Vitamin K	Vitamin K
		Pyridoxine
1940	P-Aminobenzoic acid	Alopecia as inositol deficiency
		Pantothenate
1942		Biotin structure
1945	Folic acid	Folic acid
1948	Vitamin B_{12}	Folionic acid
1955–56		Vitamin B_{12} structure

There was a need for a name for the new factors in nutrition. T name which became *vitamin* originated in this way. Funk, a Pol

chemist, coined the term "vitamine" in 1911 to designate the anti-riberi factor that he was investigating at the time. He combined *x*, to designate "essential for life," and *amine* to indicate the chemical ucture. The term was accepted and used for all of the unknown ctors. In 1919 the final "e" was dropped, for by then it was undantly clear that there were several unknown dietary nutrients d that the known ones did not all have the amine structure. The ange in spelling avoided any implication of chemical structure for e as yet unidentified dietary factors.

As a preface to the discussion of individual vitamins an explanation the general meaning of the term should be made. Vitamins are ganic compounds, necessary for growth and maintenance of life, at must be provided in the diet. The body is not able to synthesize em, at least in amounts sufficient to meet its needs. Vitamins are gulatory substances, each performing a specific function. They are rried in the blood stream to all parts of the body.

Vitamin A

In two laboratories experiments were in progress that led to the scovery of vitamin A in 1913. McCollum and Davis (*6*) at the niversity of Wisconsin fed young rats a purified diet believed be adequate at that time. It contained protein, carbohydrate, ineral salts, and fat (lard was used), all of the nutrients then recog-zed. They used milk sugar in this experiment, which added enough npurities of nutritional value for the young to grow fairly well for a hile. However, after a period the animals ceased growing. Adjust-ents were made in the relative amounts of the nutrients in the diet an effort to prevent the cessation of growth, but to no avail. When tterfat or egg yolk was added to the diet, growth was resumed. he addition of olive oil, on the other hand, had no effect. It was parent that there was a difference in the nutritive value of olive l and lard, and butterfat and egg yolk. At the Connecticut Ex-eriment Station in the same year Osborne and Mendel (*8*) fed young rats a purified diet, consisting of protein, lard, starch, and otein-free, fat-free milk which provided the minerals, some lactose, d other water-soluble substances. As in the Wisconsin experiments ter a period growth failed. With replacement of lard by butter. e rats grew and matured normally. Egg yolk and cod liver oil in e diet gave the same response as butter; these fats provided the *mething* that was lacking in the purified diet.

It was evident from the studies of McCollum, and Osborne and

Mendel, that the essential nutrient missing in the purified diets w soluble in fat. Knowing the solubility of the substance help to speed the discovery of vitamin A; many compounds were th excluded from consideration. Further help came from Steenboc studies (1919) at the University of Wisconsin in which root veg tables were fed as a source of the fat-soluble vitamin. Yellow sw potatoes and carrots supported normal growth and even suppli enough of the unknown substance for reproduction. Rutabagas, r beets, parsnips, potatoes, and sugar beets failed completely to provi the needed nutrient. Steenbock tested many plant materials, amo them yellow corn and white corn. The animals fed yellow corn a supplement to the purified ration grew normally and were able reproduce; animals fed white corn failed to grow and develop deficiency symptoms (*11*). It is interesting that McCollum, in 19 heard Wisconsin farmers who were attending a meeting at the U versity, maintain that yellow corn was better feed for hogs than wh corn; that was 11 years before Steenbock's studies confirming th contention. Thus, in addition to solubility in fat, another cha acteristic of the nutrient was recognized, the association with yello color. It had been demonstrated that animals were unable to synth size the yellow pigment, carotene. This gave a lead that it must provided in the diet. The question still remained, however, as to t relationship between the yellow plant materials and the animal substances, both of which supplied the fat-soluble vitamin. Ten yea later, in 1929, crystalline carotene was demonstrated to have vitamin value by a German scientist, V. Euler.

The properties of vitamin A and carotene

Vitamin A is an organic compound found only in the anim kingdom. It is believed to be present in all species of fish, bird and mammals. Yellow plant pigments of the carotinoid grou *alpha-* , *beta-* , and *gamma*-carotene, and cryptoxanthin are precurso of vitamin A. The body has the capacity of converting these car tinoid compounds contained in the diet into vitamin A. Actually, t origin of all vitamin A in animal products comes directly or indirect from the carotinoids of plants. Fish consume marine plankto herbivorous land animals eat vegetable foods, and the carnivoro animals depend indirectly on herbivorous sources.

Two forms of vitamin A have been identified: vitamin A_1, whic occurs in the livers of salt water fish, and vitamin A_2 found in th livers of fresh water fish. Although the two vitamins differ slight in chemical structure they are alike in physiological functions (9

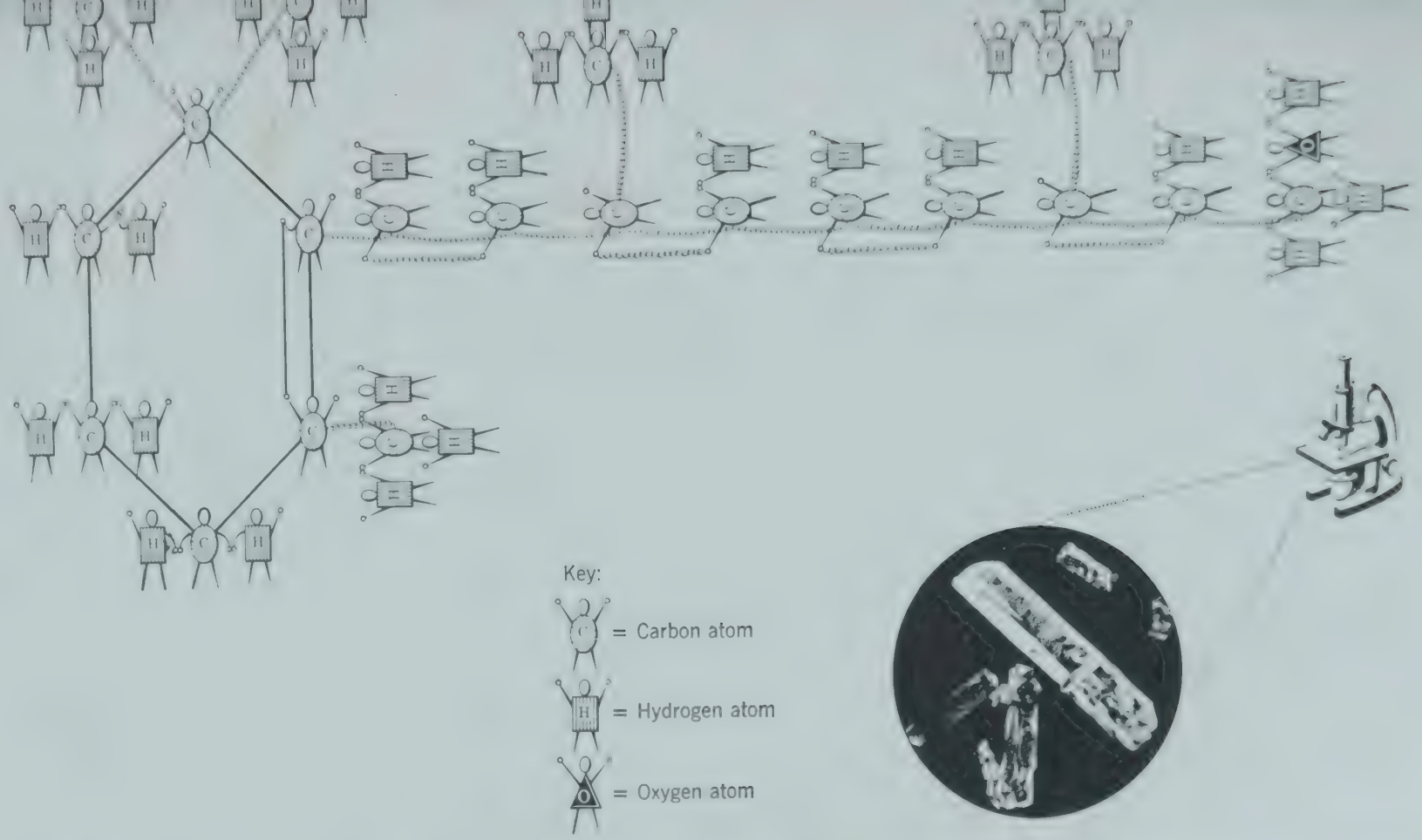


Fig. 58. Crystalline vitamin A and a diagrammatic representation of its chemical formula. Photomicrograph of vitamin A acetate courtesy of Hoffman-Lo Roche, Inc.

In the present discussion they will be treated as one, only the ter vitamin A will be used.

Vitamin A is a pale yellow substance, composed of carbon, hydr gen, and oxygen. Crystals of vitamin A with a graphic represent tion of its formula are shown in Fig. 58. It is soluble in fat, n soluble in water, stable to heat, and destroyed by both oxidation an ultraviolet irradiation.

The carotinoid pigments are compounds composed only of carbo and hydrogen. The crystals of the carotinoid pigments are a dee red color but in solution, intensely yellow. Their properties o solubility and stability are like those of vitamin A. Beta-carotene more efficiently converted to vitamin A than alpha- or gamma-caro tene, or cryptoxanthin. The chemical structure of beta-carotene such that it oxidizes to form two molecules of vitamin A; the othe provitamins form only one. However, for the sake of clarity i the discussion, we shall speak of the carotinoid group as *caroten* as though it were one substance.

Unit of measurement of vitamin A

Vitamin A is measured in International Units. The term itself in dicates the universality of the unit of measurement. The Healt Organization of the League of Nations proposed the universal un for vitamin A to replace the many different units in use at that time The International Unit of vitamin A activity as adopted by th current official body, the Subcommittee on Fat-Soluble Vitamins o the World Health Organization is equivalent to 0.3 mcg of vitami A alcohol. Equal biologic activity is afforded by 0.6 mcg of th provitamin, beta-carotene.

In the United States pharmaceutical companies use the United State Pharmacopeia (USP) Unit to express the vitamin A potency of thei products. The U.S. Unit is exactly the same as the International Un (IU). The U.S. Pharmacopeia is a book describing drugs, chemical and medicinal preparations, published under the official authority o the Food and Drug Administration.

Functions of vitamin A and the effect of a deficiency

Growth. Failure of young rats to grow when deprived of certai foods was the initial symptom that led to the discovery of vitamin A In the early studies before vitamin A had been isolated and chemica methods devised for its determination, growth rate was the criterio of measurement of the vitamin A potency in a food. Animals main tained on a vitamin-A-free diet will cease growing when the body i

pleted of its vitamin stores. Materials to be assessed for vitamin ntent were then fed in known amounts for a prescribed period time and the growth response noted. Better growth was associated with higher vitamin potency in the food.

If adequate vitamin A is not provided for normal growth, the bony ucture will suffer a growth failure before the soft tissues manifest e stunting effect. The cessation of bone growth may result in overowding of the brain and central nervous system. It now seems ear that the paralysis sometimes accompanying vitamin A deficiency very young animals is a result of failure of bone growth, causing anial pressure with consequent brain and nerve injury. In some stances there is pinching of the optic nerve, resulting in blindness.

Health of the epithelial tissues of the body. The outer surface of e body is covered with epithelial tissue, the internal cavities of the dy lined with it. The tissues are differentiated to better serve their dividual functions; the external covering is the resistant, protective pidermis; the internal tissue is a secretory mucous membrane. eficiency of vitamin A causes an abnormal condition of the epielial tissues. The specialized functions of the tissue are suppressed, nd it is transformed to a keratinized (dry, horny) type of epithelium. xcessive dryness of the skin may result from an insufficient intake; e mucous membrane may fail to secrete normally.

Xerophthalmia (also known as keratomalacia) is a condition of the ye resulting from severe deprivation of vitamin A (Fig. 59). The tear lands cease to function, the eye is dry, the cells of the *cornea* (the ransparent outer covering of the iris and pupil) become dry, and in erious cases, ulcerated. If the condition is not arrested by provision f vitamin A, blindness ensues. The cornea, the part of the eye uffering the severe damage in xerophthalmia, is an epithelial tissue. he condition occurs in both man and animal. Xerophthalmia rarely ccurs in the United States; it is common in Indonesia and South Asia. he majority of the cases occur in children two to six years of age. n 1914–1918 children in Denmark were afflicted; dairy products were hipped from the country resulting in widespread shortages at home. he condition can be developed in experimental animals deprived of itamin A.

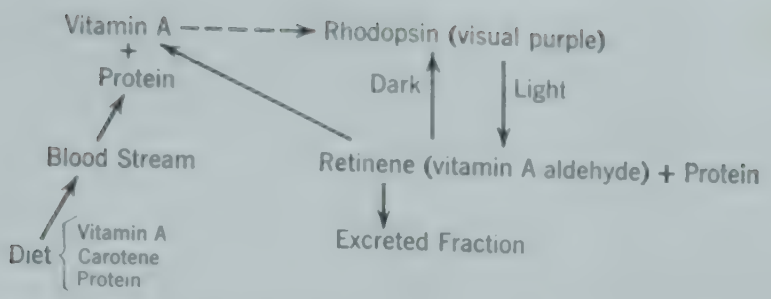
Composition and functioning of visual pigments. The retina of the eye ontains visual pigments that are a combination of vitamin A and a rotein. The retina is the perceptive structure covering the back part f the eye; it may be likened to the sensitive film of a camera on hich the image appears. Two kinds of receptor cells are in the etina—the rods which function in vision in dim light, and the cones







Fig. 59. (*a*) Beginnin stages of xeropthalmia dryness of the corne and conjunctiva whic are curable. (*b*) Th same rat as in (*a*) afte 8 days of vitamin A ther apy. (*c*) Another r with late stages of xe ropthalmia which are i curable. (Courtesy Th Upjohn Company.)



g. 60. Schematic diagram of the formation of rhodopsin. (Adapted from ddy and Dalldorf (1944) *The Avitaminoses*. The Williams and Wilkins Co., altimore, p. 66.)

hat function in bright light and color differentiation. The terms rods" and "cones" arise from the shape of the cells. Rhodopsin is he vitamin A-containing pigment in rods, iodopsin in cones (*12*).

The visual cycle of the pigments is believed to be similar; the cycle or rhodopsin (visual purple) is shown in Fig. 60. In bright light hodopsin changes to retinene plus protein with a loss of some vitamin . In the dark rhodopsin is regenerated, but additional vitamin A ust be provided from the blood stream for the process to take place Fig. 60). If sufficient vitamin A is not available, night blindness may ccur. Night blindness is characterized by inability to see in dim ght (nyctalopia) and the necessity of a prolonged time to adjust o dim light after exposure to bright light.

Metabolism of vitamin A and carotene

Conversion of carotene to vitamin A. After it was established that arotene is a source of vitamin A, the next step was to ascertain where n the body the conversion of the pigment to the vitamin takes place. t was first believed that the conversion took place in the liver. It as naturally suspected because of the high vitamin A content of the rgan. The hypothesis was questioned, however, when the pro-itamin administered intravenously was not converted to the vitamin. urther doubt was cast on that belief when the blood vitamin A was levated after feeding carotene to rats, with the liver taken out of irculation. The liver was cut off from all connections by tying off ne veins, arteries, and common bile duct. It was under the condi-ons of this experiment together with other evidence that the in-estinal wall was found to be the site of the transformation. That here may be some conversion by means other than the intestine, how-ver, has not been ruled out completely.

The amount of conversion of carotene to vitamin A is varia depending on the dietary source and efficiency of absorption. Pu crystalline beta-carotene was found to be more efficiently utilized th beta-carotene from green vegetables in studies with adults (*10*). average diets carotene is estimated to be one-half as well utilized preformed vitamin A; 3000 I.U. of carotene in the diet would be e pected to yield only 1500 I.U. of vitamin A in the body.

Absorption. Vitamin A and carotene are absorbed from the sm intestine into the lymph system. The maximum absorption is reach 3 to 5 hours after consumption.

The absorption of both vitamin A and carotene is influenced b other substances in the small intestine. Bile favors the absorption, does fat. On the other hand, mineral oil may interfere with a sorption, particularly if taken simultaneously with food, or if a lar amount of oil is fed with a less than adequate intake of the vitam Both vitamin A and carotene are soluble in mineral oil; since the oil not absorbed some of the vitamin A and provitamin A are eliminat with it. Under certain conditions, however, the oil is found not have a deleterious effect. In a study with adults, one ounce of mi eral oil taken at bed time was found not to impair the absorption either vitamin A or carotene (*5*).

Storage and excretion. In the human about 95 per cent of t vitamin A stored in the body is found in the liver. The amount least at birth and increases with age. Vitamin A is excreted by w of the bowel. In discussions of the vitamins to follow it will be not that the fat-soluble vitamins are excreted by the fecal pathway, t water-soluble vitamins by the urinary pathway.

Assessment of vitamin A status

One of the early symptoms of vitamin A deficiency is night blin ness or subnormal dark adaptation. Numerous instruments simil in principle are used for the quantitative measurement. Among the is the photometer (adaptometer) (Fig. 61), by means of which th amount of light (intensity) required for the subject to perceive o jects is measured before and after exposure to bright light. Th intensity of light and the time required to regain vision after bleac ing of the visual purple are indicative of vitamin A status. Sympton of deficiency are recognized by the need for a greater intensity light and a longer period of time required for the regeneration of th visual purple.

Various sources of error are present in this procedure, both the instrument and in the subjective response of the person bei



ig. 61. Measuring speed of adjustment from bright to dim light using an daptometer. (Courtesy United States Department of Agriculture, Washington, D.C.)

ested. Conditions other than that of vitamin A deficiency may im-air dark adaptation. If rapid and distinct improvement follows the ngestion of vitamin A, it is evident that a shortage of the vitamin was causative factor.

The blood level of vitamin A and carotene bear a relationship to ntake and are indicative of vitamin A status, within certain limits. Adults placed on a vitamin-A-free diet are found to show no change n the blood level for several weeks, followed by an ultimate lowering n the concentration. A carotene-free diet results in prompt re-luction of the blood carotene content. The body has stores of vita-nin A that can be mobilized for use, whereas carotene is not stored.

The incidence of symptoms of vitamin A deficiency in the popula-ion of this country appear to be relatively few. The capacity of the ody to store vitamin A provides for an effective emergency supply.

Hypervitaminosis A

Excessive consumption of vitamin A may result in toxic symptoms n both man and animal. Hypervitaminosis A is increasingly being

reported in both children and adults who have taken excessive dosag of concentrates of the vitamin for varying lengths of time (*3, 7, 13*). Arctic travelers who have consumed polar bear liver, which is e tremely high in vitamin A content, have manifested symptoms acute hypervitaminosis A.

The symptoms of acute toxicity are not identical in all cases, mo commonly observed are skin lesions, an itching rash in some instance in others a coarsening of the skin, thinning of the hair, and frequentl pain in the joints, with hemorrhage between the bone and its cove ing. These same symptoms may arise from other causes. A histor of consumption of excessive amounts of the vitamin and improve ment in physical condition with the discontinuance of its use led t conclusive evidence that hypervitaminosis A was the cause of th trouble in recognized cases. *Acute* toxicity may occur as an end stag of prolonged chronic toxicity resulting from overdosage over a perio of time. The toxic dose is highly variable among individual especially infants and young children, but is believed to be ove 100,000 I.U. daily. Ill effects from lesser amounts administered ove a period of time have been reported. The Council on Foods an Nutrition of the American Medical Association state that "there definite possibility of harm from the prolonged ingestion of vitami A in excess of 50,000 USP units daily" (*13*). The use of vitami concentrates that require only a few drops for a dose afford an eas means of giving more than is feasible. For example, around 50 drop of several of the common concentrates were found to yield one-ha teaspoon, providing in that small measure 15,000 I.U. of vitamin A Concentrates of the vitamin are incorporated in multiple vitami capsules in varying amounts, some contain 5000 I.U. per capsule, som 15,000 I.U. and others 25,000 I.U. and 30,000 I.U.

Recommended Allowances for vitamin A

The Food and Nutrition Board recommend daily allowances o vitamin A at levels believed to be "adequate to meet the needs o health." They are estimated to be about twice the minimal nee The recommendation for men and women 16 to 19 years of age 5000 I.U.; the same daily allowance is recommended for adults. Th allowance is made on the basis that 4000 I.U. are produced in th average diet by carotene and 1000 I.U. by vitamin A. Since caroten is only about one-half as well utilized by the body as is preforme vitamin A, if all the vitamin A activity in the diet were from caroten the allowance would be 6000 I.U. instead of 5000 I.U. On the othe

and, if all the vitamin were provided by the preformed vitamin the allowance would be 3000 I.U. instead of 5000 I.U.

Food sources of vitamin A

Preformed vitamin A occurs only in foods of animal origin; carotene is found in both plant and animal products. The most potent sources of vitamin A are fish-liver oils, liver, butterfat, fortified margarine, and egg yolk. The concentration of vitamin A in the liver increases with age and varies with the species. The potency of butterfat and egg yolk are influenced by the diet of the cow and the hen, respectively. In the spring and summer when green grass becomes more available, the vitamin A content of the milk and eggs produced by these animals privileged to enjoy it, is higher. However, the improved and enriched livestock feed used today makes possible the provision of an ample source of vitamin A in animal rations the year round.

The most important sources of the provitamin are the yellow, yellowish-red, and green vegetables and fruits. The yellow carotene in the green products is masked by the presence of chlorophyll. Among the excellent sources of carotene are carrots, sweet potatoes, apricots, spinach, tomatoes, and kale. Some vegetables and fruits deviate from the general color rule; even though yellow in color, oranges, rutabagas, and yellow wax beans are not good sources of carotene. Head lettuce and avocados, two green-colored foods, provide small amounts of carotene. Foods containing little vitamin A are nuts, grains, vegetable oils, muscle meats, and light colored fruits and vegetables. In most foods half or less of the carotene is converted to vitamin A. As a consequence, the carotene content of a food is divided by 2 in most instances to obtain the biological activity in terms of vitamin A.

The vitamin A values of some common foods are given in Table 24. The term vitamin A *value* of foods is used instead of vitamin A *content*. It would be incorrect to indicate that carrots, for example, contain 12,000 I.U. of vitamin A; actually they contain no vitamin A at all; they are rich in carotene content.

In compiling the tables of food composition published as Agriculture Handbook 8, Watt and Merrill converted mcg of carotene in foods to International Units of vitamin A activity on the basis that 0.6 mcg of beta-carotene, and 1.2 mcg of the sum of the other carotenes with vitamin A activity are equivalent to one International Unit of vitamin A.

Stability of vitamin A and carotene in foods. Since both vitamin A and carotene are insoluble in water and stable to ordinary cooking temperatures, there is little loss in food preparation. Canning and freezing cause little loss, but drying and dehydration result in considerable destruction through oxidation.

The development of rancidity in fats causes destruction of both vitamin A and carotene. Storage of fats in a cool, dry place delays the onset of rancidity and thus helps to preserve the vitamin. Margarines were found to lose less than 25 per cent of the original vitamin A content when stored at 14° F for a period as long as 2 years, but when stored at 64° F, 75 per cent of the original vitamin A content was lost in only 17 weeks (*2*).

Table 24. Vitamin A Value of Some Typical Foods

Food	Measure	Vitamin A Value, I.U.
Liver, beef, cooked	2 slices	45,495
Spinach, cooked	⅔ cup	14,132
Potatoes, sweet, cooked	1 medium	11,410
Carrots, raw	⅔ cup	8,800
Mustard greens, cooked	⅔ cup	6,700
Kale, cooked	⅔ cup	6,147
Broccoli, cooked	⅔ cup	3,400
Apricots, canned	4 med. halves	1,650
Peaches, raw	1 medium	880
Eggs, whole	1 medium	550
Banana	1 medium	430
Ice cream, plain	⅐ quart	420
Milk, whole	1 cup	390
Cheese, cheddar	1 ounce	375
Lettuce, head	4 small leaves	270
Butter (average)	1 pat	230
Margarine, fortified	1 pat	230
Orange juice, fresh	½ cup	230
Apple, raw	1 medium	120
Pecans	1 tbsp.	trace
Oatmeal	⅔ cup	0
Bread, whole wheat	1 slice	0

From *Composition of Foods—Raw, Processed, Prepared.* U.S. Department of Agriculture, Agriculture Handbook 8, 1950.

A guide to meeting the daily need for vitamin A

A guide to food combinations that will supply the day's need for vitamin A for college men and women is given in Fig. 62. Vitamin

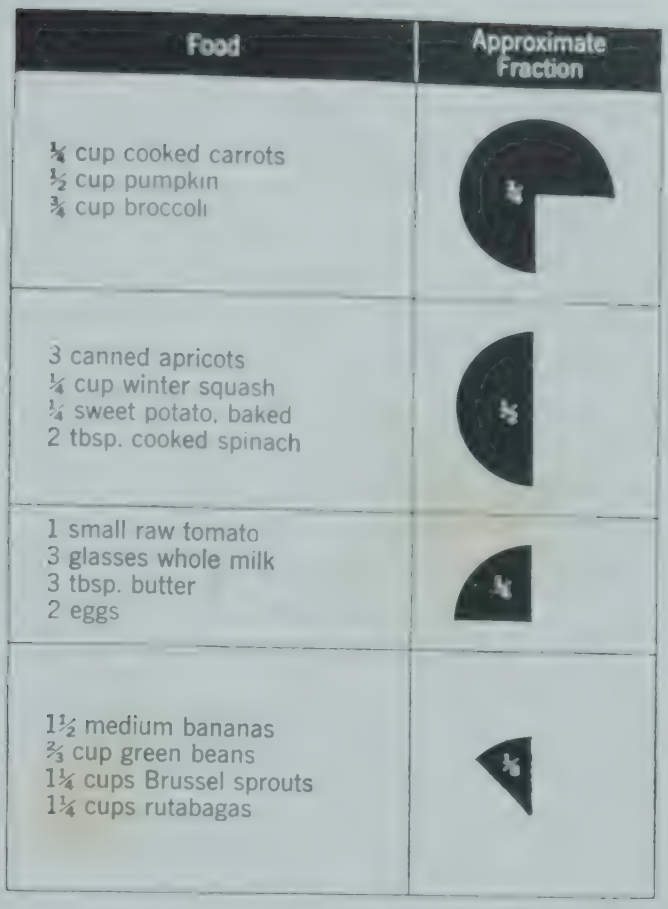


Fig. 62. The amount of an individual food needed to provide a certain fraction of the day's Recommended Allowance of Vitamin A for college men and women.

A is one of the essential nutrients that diets of students, in fact of the population as a whole, seem most likely to contain in less than recommended amounts.

Vitamin D

Vitamin D will prevent and cure rickets, a disease in which bones fail to calcify. Children were afflicted with rickets for many centuries before the cause of the disease and the cure for it were known. In Central Europe, rickets was known as "The English Disease" because of its prevalence in England. In that country around 1900 it reached almost epidemic proportions when industrialization resulted in both parents working in shops, leaving little time for taking babies out of doors. Rickets was not confined to England by any means, however. It was common in most of the countries of Northern Europe as well, and in the larger cities of the United States, where

as recently as 35 years ago the disease was still common. The di
covery of vitamin D and subsequently its widespread use has spar
children the crippling effects of rickets.

A combination of clinical observations of children afflicted wi
rickets, and of experimental animals in which rickets had been d
veloped under controlled laboratory conditions, led to the identific
tion of vitamin D as the *antiricketic vitamin*. An early (1890) signi
icant observation, made by Palm an English physician, was that t
incidence of rickets is related to the amount of sunshine availabl
where sunshine was abundant, rickets was rare; where the sun seldo
shone, rickets abounded. A few years later, the concept develope
that rickets, like scurvy and beriberi, might be a dietary deficienc
disease. With that possibility in mind, the expected next step was t
produce the deficiency in experimental animals. In 1921 Mellanby i
England produced rickets in puppies, using a mixture of natural food
then induced recovery by giving them cod liver oil. At that tim
cod liver oil was known to contain only vitamin A, so the cure wa
attributed to it (7). Later it was discovered that even after the vita
min A content of cod liver oil was destroyed by certain treatment
the antiricketic potency still remained. It was then that it becam
evident that cod liver oil contained two vitamins, vitamin A and th
antiricketic factor (*5*). In the meantime, the association of ricket
with calcium and phosphorus metabolism, and the favorable influenc
of cod liver oil on the utilization of calcium were recognized.

By 1922 the mystery of the effectiveness of sunlight in preventin
rickets was on the way to solution. Rats fed a rickets-producing diet
failed to develop rickets if exposed to sunlight (*2*). Furthermore, rat
fed a rickets-producing diet that had been irradiated in the laboratory
given the same effect as exposure to the sun, also failed to develo
rickets (*12*). Following the discovery of the effectiveness of irradi
ating the diet as a whole, each item was removed, one at a time an
treated separately, then incorporated into the diet in an effort t
determine which nutrient was responsible for the antiricketic effect
Fat was the only nutrient that on irradiation imparted antiricketi
potency to the diet. With fats established as potential antiricketi
factors, the next question to be solved was which portion of the fats
the alcohol (glycerol) or fatty acid fractions, became *activated* o
exposure to the ultraviolet rays. It was found to be the alcohol por
tion. Intensive research soon disclosed that numerous alcohols, all o
which belonged to the sterol group of alcohols, acquired antiricketi
activity on irradiation. The sterols are much more complex in chemi
cal structure than the common medicinal and beverage alcohols.

By the late 1920's it had been established that rickets could be prented and cured by exposure to direct sunlight, by irradiation with traviolet light, by feeding irradiated food, and by feeding cod liver l. Then followed the identification of the *natural* vitamin D of sh liver oils as the same substance produced in the skin on irradiaon, 7-dehydrocholesterol, designated as vitamin D_3, and the recognion that irradiation of plant foods produces a different substance, esignated as vitamin D_2. Now it is known that the vitamin D in od liver oil is chiefly D_3 but contains some of D_2 also.

he properties of vitamin D

The sterols that are potential sources of vitamin D are known as rovitamins. There are many of them, but only two of importance, -dehydrocholesterol and ergosterol. The provitamin in higher anials and invertebrates is 7-dehydrocholesterol; ergosterol is present n the plant kingdom, in yeasts and certain molds.

The pure vitamins D are white, crystalline, odorless substances that re soluble in fats and fat solvents such as ether, chloroform, acetone, nd alcohol. The vitamins are comprised of carbon, hydrogen, and oxygen, combined in chemical structures that are much alike. Crysals of vitamin D and its chemical structure are shown in Fig. 63. The relative antiricketic potency of vitamin D_2 and D_3 appear to be o different for the human; consequently in the present discussion we will simply use the one term, *vitamin D*.

he unit of measurement of vitamin D

Vitamin D potency, like that of vitamin A, is expressed in Interational and USP Units. (Other vitamins are measured in units of veight.) The amount of antiricketic activity brought about by 0.025 mcg of the International Standard, pure crystalline vitamin D_3 is an nternational Unit. The unit was adopted by the World Health Organization in 1949, and has been used ever since. The USP Unit is he same as the International Unit.

In order to measure the *amount of antiricketic activity*, rats are sually employed as the experimental animal. Under standardized onditions of feeding and care, and by using standardized procedures or determining bone change, the potency of vitamin D in terms of nternational Units is determined.

Conversion of provitamin D to the vitamin

The conversion of provitamin D to the vitamin outside the body s not a simple reaction and results in the conversion of only 40 to

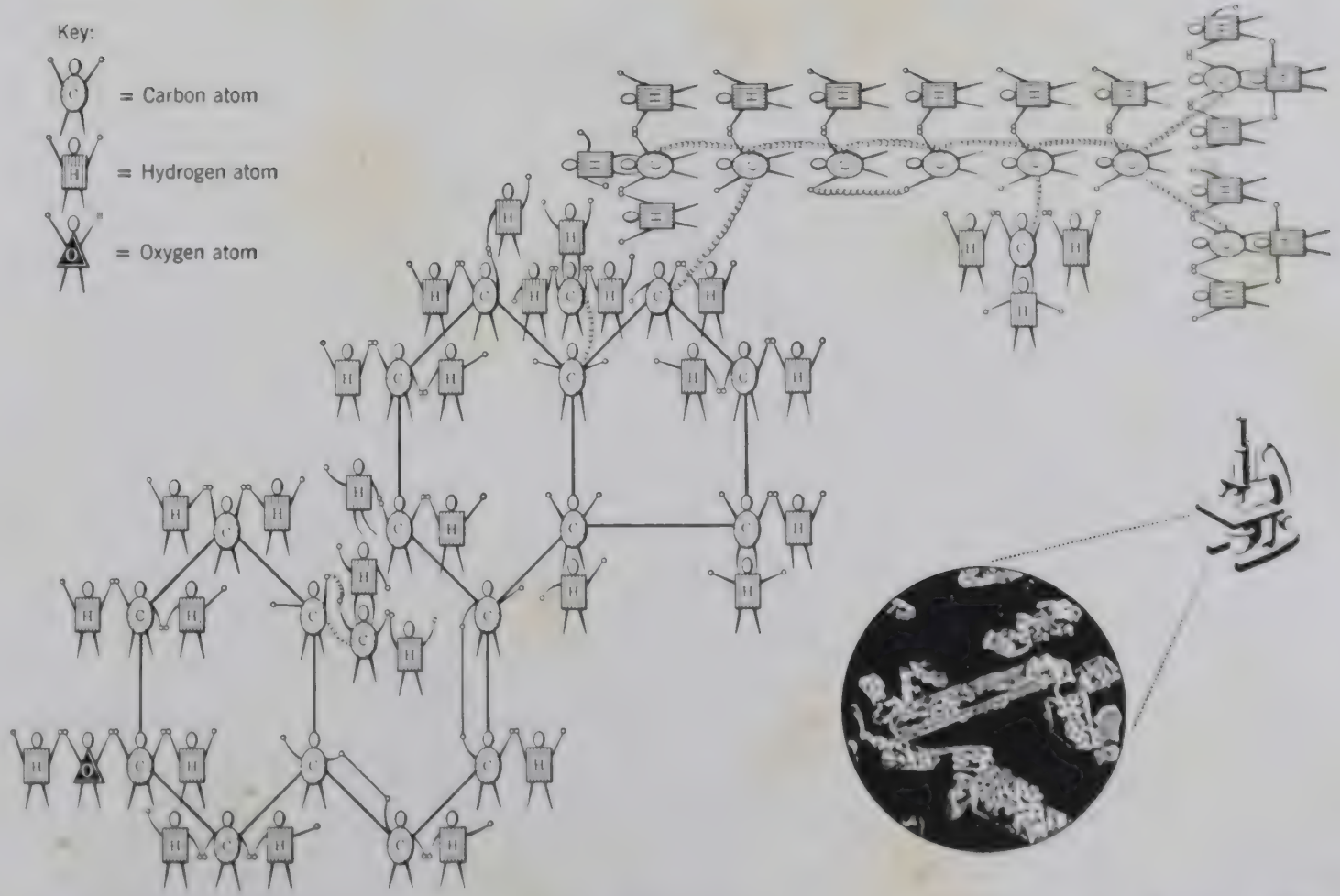


Fig. 63. Crystalline vitamin D (calciferol) and a diagrammatic representation of its chemical formula. (Photomicrograph courtesy Distillation Products Industries Division of Kodak, Rochester, N.Y.)

per cent of the provitamin to the vitamin. During irradiation a ries of intermediary products are formed before vitamin D is obned; further irradiation beyond the vitamin D stage produces toxic oducts lacking antiricketic potency.

nctions of vitamin D and the effect of a deficiency

Bone formation. One of the chief functions of vitamin D is the aintenance of the normal processes of bone formation (*4*). A deciency of the vitamin in the growing young results in rickets. The sease will develop in infants even though the diet provides an ample take of calcium and phosphorus unless vitamin D is provided in the et or adequate exposure to sunlight is possible. Late rickets (osteoalacia), a condition similar in nature, occurs in adults.

In rickets the bones are susceptible to deformity when exposed to rdinary stresses. A common and severe change in the skeletal structure is enlargement of the ends of the long bones in the legs and arms. mineral is not deposited in the developing bone cells, the weight



ig. 64. Ricketic rosary showing enlargement of costochondral junctions. From Wolbach and Jolliffe, Tisdall, and Cannon (1950), *Clinical Nutrition.* Paul B. Hoeber, Inc., New York, p. 113.)

of the body causes the noncalcified portion to flatten and mushroo outward, giving the appearance of enlarged joints. Other bon changes include the *ricketic rosary*, a row of beadlike protuberance on each side of the chest at the juncture of the rib bones and joinin (costal) cartilage (Fig. 64), bowed legs, and knocked knees—a caused by failure of the bones to calcify normally.

The mode of action of vitamin D in relation to bone calcificatio remains relatively obscure. Intramuscularly injected radioactive ca cium was deposited in the bones of ricketic chicks with no vitamin I in the diet. This indicated to the investigators that the primary func tion of vitamin D might be that of facilitating absorption of calciu from the intestine since calcium deposition in bones could proceed without it. When calcium was placed in the tissues by injection eliminating the need for absorption, it seemed also to eliminate th need for vitamin D (*8*).

Calcium absorption and metabolism. Evidence that vitamin I exerts a favorable influence on the absorption of calcium during rickets is illustrated in the values given in Fig. 65. In rickets the feca excretion is markedly reduced after the administration of vitamin D With children 1 to 12 years of age, Jeans and Stearns found that some utilized calcium efficiently without added vitamin D; others required a supplement. Stearns pointed out that there is no way of discerning from outward appearances which children need the additional vita min, which do not, hence recommended that vitamin D be given to al children (*10*). Numerous balance studies with normal adults show

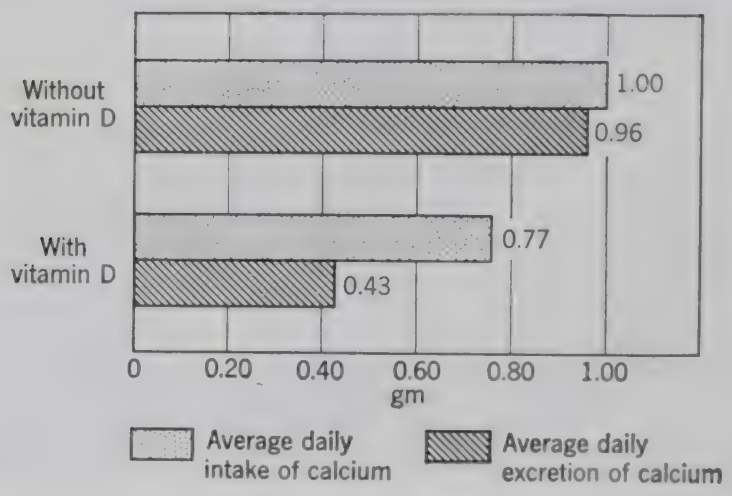


Fig. 65. Influence of vitamin D (cod liver oil) on calcium metabolism of infant with rickets. (Adapted from Hess (1929), *Rickets*. Lea and Febiger, Philadel phia, p. 161.)

improvement in the utilization of calcium with additions of sources vitamin D (*6*), indicating that the intake is sufficient to supply whatever need there may be without a supplement.

The absorption of phosphorus is less directly influenced by vitamin than is calcium. In the absence of calcium, vitamin-D-deficient animals absorb phosphorus equally well, with and without an additional supplement of the vitamin.

Growth. Rickets causes a slowing of growth. Animals in which experimental rickets has been induced grow more slowly than their normal controls with an adequate vitamin D intake. Infants also fail to grow normally without a sufficient amount of the vitamin. Infants given 340 to 400 I.U. daily of vitamin D were found to grow more in length than those receiving 60 to 135 I.U. Giving more than 600 I.U. daily did not increase the growth rate further (*9, 11*); increasing the vitamin D intake beyond 1800 I.U. daily decreased growth (*11*).

Incidence of vitamin D deficiency

Clinically detectable rickets is uncommon in the United States today. The widespread preventive (prophylactic) use of sources of vitamin D has all but eradicated this once common scourge of infancy. Fortification of all evaporated milk and much of the fresh milk with vitamin D almost controls rickets automatically in the United States. Osteomalacia, too, is rare in this country. It is reported to be common among women in the Orient and parts of the Near East during pregnancy and lactation, increasing in severity with each reproductive cycle.

Metabolism of vitamin D

Vitamin D can be made available to the body through food sources or concentrates and by activation of the provitamin, 7-dehydrocholesterol, in the skin. The vitamin taken by mouth is absorbed from the small intestine chiefly by way of the lymph system. The process is facilitated by the presence of fat. Bile is necessary for normal absorption of the vitamin from the intestine. Excretion of vitamin D is by way of the bowel, with no excretion through the kidney.

During lactation there is some transmission of vitamin D into the milk. The amount increases with a more ample intake of vitamin D in the diet or exposure to sunlight. Summer milk contains more of the vitamin than winter milk. The laying hen, with vitamin D in the ration, transmits a portion of it to the egg yolk.

Hypervitaminosis D

Massive dosages of vitamin D may have toxic effects if continue for a period of time. Giving only two massive doses a year is use by some physicians as an acceptable means of providing vitamin D The level at which deleterious effects result from continued hig dosages varies with individuals. Some show symptoms with an intak of 50,000 I.U. per day for a few weeks, others tolerate as much ten times that amount for longer periods of time. An intake of 18 I.U. daily may be mildly toxic in children if continued over a perio of time. The early symptoms include loss of appetite, thirst, lassitud followed by nausea, vomiting, diarrhea, abdominal discomfort, an loss of weight. The blood calcium and phosphorus levels are elevate with increased excretion of calcium in the urine, which tends to cau deposits in the kidney with consequent damage to the organ and im paired function. In hypervitaminosis D, cells in various organs o the body, as well as the arteries and arterioles, become susceptible t abnormal deposition of calcium. Severe intoxication with widesprea calcification of soft tissues ultimately may prove fatal if massiv dosages are continued. Acute toxicity may result from a chron condition that has been present for some time becoming acute onl when a high degree of toxicity is reached.

Vitamin D preparations on the market are of such potency tha dosages are expressed in drops, making it easy to give more than desirable (*1*). In commonly used preparations around 50 drop measure one-half teaspoon with a potency of 3,000 I.U. Most multi ple vitamin capsules provide 500 I.U. or more per capsule.

Recommended Allowances for Vitamin D

The Recommended Allowance for vitamin D for late adolescenc and young adulthood (16 to 19 years) is 400 I.U. daily, the same a is recommended throughout childhood.

Normal adults seem to need little, if any, supplemental vitamin D Calcium retention is not improved by the vitamin, except in wome during pregnancy and lactation. It is generally believed, nevertheles that for adults with little exposure to the direct sunlight, some vita min D in the diet may be advisable, despite lack of direct proof t substantiate the presumption. During pregnancy and lactation, whe the calcium need is increased, the Recommended Allowance is 40 I.U. daily. The requirements of infants and children, and furthe discussion of the needs during pregnancy and lactation appear i those respective subsequent chapters.

urces of vitamin D

Vitamin D is not widely distributed in nature. The best sources fish oils, especially liver oils, the concentration of which varies ch the species as shown in Table 25. Milk, butter, and egg yolk the only foods in the ordinary diet that contain vitamin D and in se the amount is small and variable, with the exception of milk to uch vitamin D is added in amounts to meet the standard for vitamin milk, 400 I.U. per quart.

There are fish liver oils on the market and concentrates of ir-diated ergosterol; also vitamin D is included in many multiple vita-n combinations. Some of the preparations of vitamin D are in oily

Table 25. Vitamin D Content of Various Fish Oils

Source	I.U./gm of oil
Swordfish, liver	10,000
Black Sea Bass, liver	5,000
Chinook salmon, liver	1,300
Halibut, liver	1,200
Boston Mackerel, liver	750
Cod, liver	100
Haddock, liver	10
Sturgeon, liver	nil

From Bills, *Physiol. Revs.* **15**: 13, 1935.

olution, some are aqueous preparations. The potency as indicated n the label is assured of accuracy by the reliability of the pharmaceu-cal house manufacturing the product and the surveillance of the ederal Food and Drug Administration over the authenticity of bels.

Exposure to sunshine or ultraviolet irradiation results in the syn-nesis of the vitamin; the provitamin, 7-dehydrocholesterol, which ccurs in the skin and in the blood (*3*), is transformed into vitamin . The amount that can be synthesized by man by this method is ot known. Smoke, haze, and fog in the atmosphere, the glass in the indows, the clothing worn, the pigmentation of the skin, all inter-ene to limit the ultraviolet light exposure of the skin. In the sum-er time, the vitamin D value of sunlight in the United States reaches e greatest intensity of the year; in December it is least. The rays f the rising and setting sun are less effective than the sun at midday.

Vitamin E

Research which eventually led to the discovery of vitamin E w conducted in the early 1920's by Mattil, Evans, and Sure. Duri an investigation of the influence of diet on the reproductive cycle the rat, it was found that rats became sterile when reared on a purif diet, which contained all of the then known nutrients. Even thou the experimental animals fed this ration appeared to be quite health they were not able to produce young. When fresh green leaves dried alfalfa were fed to these sterile animals, reproductivity was r stored in the female but not in the male of the species. The u known factor, which prevented sterility, was first called substance and later was named vitamin E.

Properties of vitamin E

The chemical name for vitamin E is tocopherol. Actually, the are four different tocopherols which collectively are called vitamin This vitamin occurs as a yellow viscous oil that is insoluble in wat but soluble in all the fat solvents. Although vitamin E is quite stabl to acids and heat (in the absence of oxygen), it is readily destroye by ultraviolet light, alkalies, and oxygen.

Among the fat-soluble vitamins, vitamin E is unique in that it is naturally occurring *antioxidant*. An antioxidant is a substance whic delays or retards oxidation in biological materials where hydroge atoms are missing in the carbon chain.

Function of vitamin E

It has long been believed that the function of vitamin E in th animal organism is directly related to its antioxidant property. Be sides its possible function as an activator in certain enzymatic reac tions, it plays an important role in the protection of vitamin A, caro tene, and ascorbic acid from oxidation both in the digestive tract an in the body cells. Because of this, the body apparently makes bette use of food vitamin A and ascorbic acid.

The effects of a vitamin E deficiency

In animals and birds. Vitamin E has been shown to be essentia for animals and birds, including the rat, rabbit, dog, guinea pig, chick and duck. The most characteristic deficiency symptoms, however occur in the rat and in the rabbit.

When rats are fed rations deficient in vitamin E, permanent sterilit in the male and temporary sterility in the female result. The per manent sterility of the male rat, which is caused by a degeneration o

e cellular material of the testes, cannot be relieved by vitamin E erapy. In contrast to this, conception does occur in the deficient male rat but about the eighth day of pregnancy, the fetuses, or unborn animals, die and are resorbed. However, if vitamin E is added the rations of these sterile females, their next pregnancy will be ormal and they will produce living, healthy young. One of the easons postulated for the death of the unborn young is the lack of an dequate blood supply to the fetus because of a change in the permeability of the reproductive tissues.

Young rabbits develop a condition called muscular dystrophy when ney are fed a ration deficient in vitamin E. This disorder, which is haracterized by a loss of muscle tone and a general weakening of the uscles, is quickly relieved when vitamin E is added back to the tion.

In man. At this time there is no conclusive evidence to indicate hat vitamin E is essential to man. It should be noted, however, that he plasma level of alpha tocopherol is lowered in normal adults after haintenance on a limited intake (2 mg daily in contrast to an estiated average of 15 mg daily for the supplemental group) for a period rom 10 to 22 months. No clinical or physiological effects were obrved to accompany the lowered plasma level during the period of bservation. The findings indicate that the blood tocopherol level is ependent on the intake of the factor (*1*). Vitamin E does not seem o have any effect either in the relief of sterility in humans or in the ure of human muscular dystrophy.

ecommended Allowances for vitamin E

At the present time, no vitamin E recommendation for man has een suggested. Because vitamin E is so widely distributed in the oods of the diet, it is doubtful that a vitamin E deficiency would ver develop in the human.

ood sources of vitamin E

Inasmuch as vitamin E occurs mainly in plant materials, the richest ources of the vitamin are found in vegetable oils (such as wheat germ il and cottonseed oil), green leafy plants and vegetables, as well as hole grain cereals. Although animal products contain little of the itamin, liver, heart, kidney, milk, and eggs are the best animal sources f vitamin E.

Vitamin K

In 1929 Dam, a Danish scientist, reported that chicks raised on a ynthetic diet developed hemorrhages under the skin that could not

be relieved with the addition of ascorbic acid to the ration. This d
order, which was characterized by a prolonged blood clotting tir
disappeared when a mixture of cereals or natural foods was given
the birds. Later, Dam found that this antihemorrhagic factor w
present in the fat-soluble fraction of certain foods. He suggest
it be called vitamin K, derived from the Danish term, "Koagulati
Faktor."

Properties of vitamin K

This yellow-colored vitamin is stable to heat, unstable to alkali
strong acids, oxidation, and light. Although vitamin K is classed
a fat-soluble vitamin, one of its more widely used forms, menadio
which is synthetic, is water-soluble.

There are two antivitamins K, dicoumarol and hydrocoumarol, th
are used in medicine in the relief of human thrombosis, a disord
in which clots are formed abnormally in the blood stream. An ant
vitamin functions in the opposite way from the vitamin and aids
dissolving the blood clots. Actually in medical practice, the ant
vitamins of K are used more widely probably than the vitamin itse

Function of vitamin K

Vitamin K is essential for the synthesis of prothrombin which is
precursor of thrombin, one of the factors needed for normal bloo
coagulation. Even though the production of prothrombin apparentl
occurs in the liver, the exact function of the vitamin in this synthes
is not known. It has been suggested, however, that vitamin K ma
be an essential part of the enzyme system involved in the productio
of this blood clotting factor.

The effects of a vitamin K deficiency

In birds and animals. Chicks fed a ration deficient in vitamin
develop a fatal bleeding disorder which is characterized by a pro
longed clotting time of the blood. This disorder, however, may b
relieved by the administration of vitamin K. It is commonly believe
that vitamin K deficiency is an avian characteristic. In recent studi
rats maintained on a vitamin K-free diet, when access to their fece
was completely prevented, developed a bleeding tendency (*1*). Som
vitamin K is synthesized in the small intestine by bacteria.

In man. Vitamin K deficiencies in man result most often fro
either a faulty absorption of the vitamin or liver disorders that inter
fere with the synthesis of prothrombin, rather than from a dietar
lack of the nutrient. Inasmuch as vitamin K is supplied to the bod

the food intake plus the synthesis by microorganisms in the intinal tract, there usually is an adequate supply of the vitamin available to the body. Sometimes, however, the intake of large amounts sulfa drugs or other antibiotics may destroy the microorganisms hich synthesize the vitamin and the supply may be low. Because tamin K is fat-soluble, the presence of bile is necessary for its abfption as was true with the absorption of fats and the other fat luble vitamins. Therefore, when disorders of the liver or gall adder interfere with the secretion of the bile fluid, a vitamin K fficiency may occur. For example, in cases of obstructive jaundice, here a blockage of the bile duct prevents bile from flowing normally to the intestine, vitamin K is not adequately absorbed. On the her hand, in certain liver disorders, such as cirrhosis, adequate vitain K may be absorbed, but the synthesis of prothrombin does not ccur because of the damage to the liver cells themselves.

In addition to this, new born infants may have inadequate vitamin supplies because the right types of microorganisms may not have ad a chance to become established in the intestinal tract.

ecommended Allowances for vitamin K

The Food and Nutrition Board (*2*) states that the amount of vitain K required for maintenance of a normal prothrombin level in the lood is easily provided when an average diet is ingested.

The newborn infant has lowered blood serum levels of prothrombin hich decrease further during the first week of life, but spontaeously return toward the adult level in subsequent weeks. As a onsequence, it has been a fairly common practice to routinely adinister vitamin K to the mother prior to delivery or to the very oung shortly after delivery. More recently the practice has been uestioned—it has been difficult to demonstrate that decreased levels f coagulation factors are a direct cause of hemorrhage of the newborn (neonatal), and, there is not complete agreement that routine adinistration of vitamin K in pregnancy affects the incidence either. o the Board (*2*) has recommended that:

> n the absence of liver disease, there seems to be no reason to supplement aternal diets in this country with vitamin K except in conditions conucive to neonatal hemorrhage such as prematurity.

ood sources of vitamin K

Vitamin K occurs in plants; good sources are alfalfa, cauliflower, abbage, spinach, kale, and soybean. In contrast, fruits, cereals, and nimal products contain little vitamin K.

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CHAPTER 14

Ascorbic acid

Many of you have read in history books that the early explorers o both land and sea were menaced by outbreaks of a disorder calle *scurvy*, which is a nutritional disease caused by a severe deficiency o ascorbic acid. The exploration of the world, during the fifteenth an sixteenth centuries, was hindered by the outbreaks of this malad among the men of many expeditions. On Vasco de Gama's famou voyage around the Cape of Good Hope in 1497, as many as two thirds of his crew died of scurvy. All the members of Jacque Cartier's second voyage to Newfoundland, in 1553, suffered from thi disorder when they were forced to spend the winter in Quebec. Be cause fresh foods were not available, some of the crew died from scurvy before the Indians taught them to prepare a tea of the bark and leaves of the spruce tree which acted both as a remedy and a pre ventative for the disorder.

James Lind, a ship's surgeon in the English Navy, had the geniu to observe, record, and experiment with scurvy patients on boar the H. M. S. Salisbury in 1747, and his classical work led to the elim ination of scurvy among the crews of ships. He made the follow ing report of his experiences in relieving scurvy on this now famou voyage (*4*):

On the 20th of May 1747, I took twelve patients in the scurvy . . Their cases were as similar as I could have them . . . They lay together i one place and had one diet common to all . . . Two of these were ordere each a quart of cyder a-day . . . Two others took twenty-five gutts o

ir vitriol[1] three times a-day . . . Two others took two spoonfuls of inegar three times a-day . . . Two of the worse patients were put under course of sea-water . . . Two of the others had each two oranges and e lemon given them every day . . . The two remaining patients took e bigness of a nutmeg three times a-day of a electuary[2] recommended by hospital surgeon . . . The consequence was, that the most sudden and sible good effects were perceived from the use of the oranges and lemons; ne of these who had taken them, being at the end of six days fit for duty . The other was the best recovered of any in his condition; and being w pretty well, was appointed nurse to the rest of the sick . . .

Not only did Lind show that scurvy could be cured by the intake orange and lemon juice, but also he developed a method for the ncentration and preservation of the juices from citrus fruit for use sea. In 1795, the Royal Navy began to provide a regular daily tion of lime or lemon juice to all its men, and the name "limey," hich is used to describe an English sailor, reflects back to this ractice.

Throughout the nineteenth century, there are records of scurvy idemics in different parts of the world. The most famous epidemic as the potato famine of 1845–1848, which killed many people in eland where potatoes were the main food of the diet. Even the ttlers of our own country suffered from scurvy in their march estward. In 1846–1848 the Mormons, on their way to Utah, were rced to spend the winter near Omaha, Nebraska. Here they lived n a diet that consisted primarily of mush with the result that 300 hildren and adults died, most of them of scurvy.

Although man has known for years that the use of certain kinds f foods in his diet would prevent the occurrence of scurvy, it was ot until 1933 that Waugh and King at the University of Pittsburgh nd Szent-Gyorgyi in Hungary identified the antiscurvy factor as scorbic acid. Since that time, the vitamin has been manufactured n the synthetic form and today can be purchased at a very low cost.

roperties of ascorbic acid

Ascorbic acid is the chemical name for vitamin C; it occurs in white rystals that are easily dissolved in water (Fig. 66). Although the rystals of the vitamin are quite stable in the dry form, a water olution of ascorbic acid will undergo destruction when exposed to ir, heat, light, or metals like copper and iron. It is unstable in alkali nd relatively stable in an acid medium.

[1] A strong solution of sulfuric acid combined with aromatics.
[2] Made of garlic, mustard seed, *rad-raphan*, balsam of Peru, and gum myrrh.

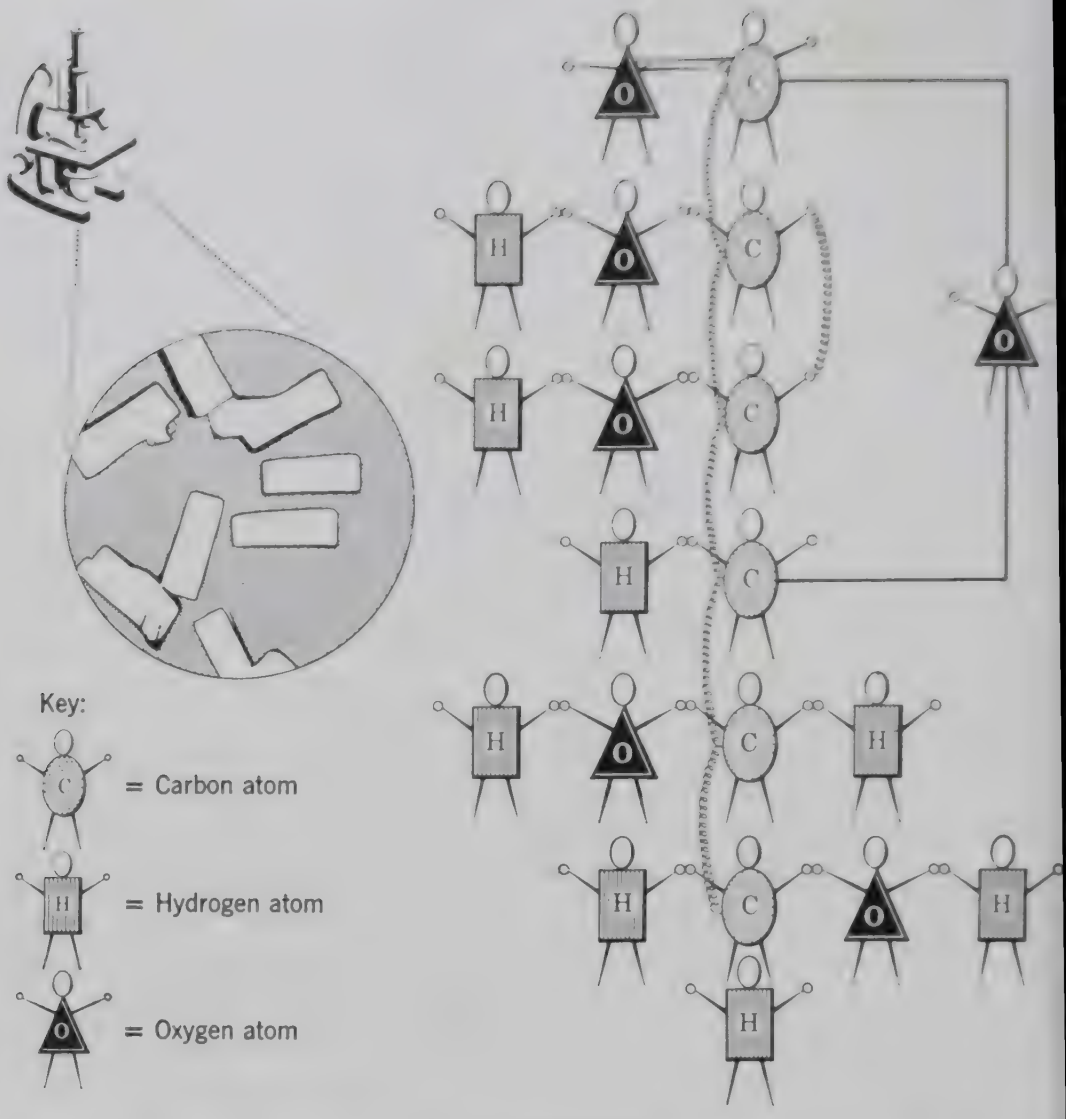


Fig. 66. Crystalline ascorbic acid a diagrammatic representation of the chem ical formula. Photomicrograph courtesy Merck and Co., Rahway, N.J.

Until only recently, just one form of the vitamin, called *reduce* ascorbic acid, was recognized as giving vitamin protection to man Now, however, another form of the vitamin has been found that can be used as well as the reduced form, and it has been named *dehydr* ascorbic acid. The sum of the vitamin effect from both reduce and dehydroascorbic acids is referred to as *total* ascorbic acid Recent experiments, conducted to determine how efficiently college students were able to utilize the total ascorbic acid from twenty-four different fruits and vegetables, have shown that the dehydro ascorbic acid was used as well as the reduced form (*3*). The foods tested were asparagus, blackberries, black raspberries, broccoli, Brussels

routs, cabbage, cantaloupe, cauliflower, collards, green beans, green as, green peppers, kale, Lima beans, orange juice, peaches, potatoes, rawberries, sweet potatoes, Swiss chard, tangerines, tomatoes, tomato ice, and turnip greens (*2*).

nctions of ascorbic acid

Although the exact way that man and animals use ascorbic acid is ot yet well established, it is known that this vitamin is important the formation and maintenance of the *cementing material* that holds e cells of the body together. In addition to this function, it has een suggested that ascorbic acid is related (1) to the normal metabo- sm of the amino acid, tyrosine, (2) to the body's ability to resist acterial toxins, and (3) to the function of the adrenal gland.

The human body is composed of many organs as well as different inds of tissues, and each organ or tissue is made up of many, many ells. These cells are held together by a cementing material called *ollagen* (Fig. 67). When the body's supply of ascorbic acid is low r lacking, the collagen between the cells begins to disappear and the ells of the organs or tissues are no longer held together.

The role of ascorbic acid in the formation and maintenance of this ollagen was first observed in a study using guinea pigs that was onducted at Harvard University (*6*). When the tissues of these corbutic animals were examined under the microscope, it was found hat the collagen material between the cells had disappeared. Similar xaminations of the teeth and bones of the animals revealed that the ells of the dentin, the interior part of the tooth, and those at the nd of the long bones were affected.

Collagen is also an important factor in the healing of cuts or wounds. n cases of wound healing when the intake of ascorbic acid is below ormal, it has been demonstrated that wounds do not heal normally.

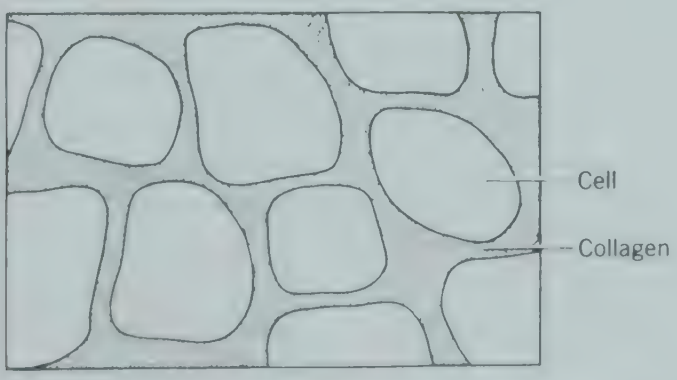


Fig. 67. A sketch showing collagen structure between the cells.

The complete repair of the tissue cannot be made because of the sm amount of collagen present to hold the new cells together.

Three of the symptoms of scurvy that we can directly relate to t loss of the cementing action of collagen are (1) the hemorrhages th occur throughout the body, (2) the loosening of the teeth, and (the changes in the cells that occur in the extremities of the long bon of children and young animals. There is no doubt at the prese time that a deficiency of ascorbic acid is directly related to po collagen formation in the body, but the biological role of the vitam in this reaction is still unknown.

The effects of an ascorbic acid deficiency

In animals. The only animals other than man that have a dieta need for ascorbic acid are guinea pigs and primates (monkeys, ap chimpanzees). Other animals need the vitamin but they are able synthesize enough ascorbic acid in their body tissues to meet t requirement.

When guinea pigs are placed on an ascorbic acid-free diet, th begin to lose weight rapidly after 16 days and between 25 and 28 day they will die if the vitamin is not restored to the ration. Loss appetite as well as dull and rough hair are the characteristic gro symptoms of this disorder. There are also signs of marked hemo rhages throughout the tissues and organs of the body when the anima are autopsied.

In man. Human scurvy is rarely found in the United States toda The few cases that do occur are found in infants between the ag of 6 and 12 months who have not received adequate amounts of th vitamin in their diets, and in aged or older adults who have poor foo habits.

Adult scurvy. The first symptoms of scurvy that precede th clinical lesions of the disorder are weakness, loss of weight, and flee ing pains in the arms and legs. Usually the first noticeable clinic symptom is the formation of a horny growth in the hair follicles calle *follicular keratosis* which may occur on the legs, buttocks, arms, an back. This is followed by the appearance of redness (hemorrhages around the hair follicle. Soon the scorbutic changes in the gum become apparent. It has been observed in cases of experimentally in duced scurvy that the gum lesions begin to appear after 26 week of ascorbic acid deprivation. At first, the gums are red and swolle and as the disorder progresses, the swelling increases, hemorrhage occur, and the gum tissues take on a blue-red color. If the conditio persists, the teeth may become loosened.

The failure of new wounds to heal and the tendency of old wounds become red and break open has been observed in scurvy patients centuries. This incapacity for wound healing, however, was first monstrated in 1940 when Crandon used himself as an experimental ject and ate an ascorbic acid-free diet for a period of 6 months (*1*). the end of this dietary restricted period a wound was made in e mid-area of his back to observe the effect of the vitamin privation on the formation of collagen tissue during healing. Ten ys after the wound was made an examination showed that only e surface cells had knitted together and that the inside of the wound d not healed (Fig. 68). Yet, 10 days after ascorbic acid had been t back in his diet, normal healing was observed upon the examina- n of the same wound.

Subclinical scurvy. In this country, some people who have low in- kes of ascorbic acid in their diets undoubtedly suffer from sub- inical or mild cases of scurvy. Nevertheless, it is impossible to scribe lesions which might occur in these mild cases because of the nspecific nature of the symptoms of scurvy. Crandon, in his assical self-induced scurvy investigation, showed the symptoms of eat weakness by his inability to perform work in addition to the ability to heal wounds. However, one of the characteristic symp- ms of scurvy, the changes in the gums, did not occur even after x months of ascorbic acid deprivation. Arctic travelers, trappers, d Eskimos are known to live on a daily ascorbic acid intake of less an 15 mg without showing any clinical symptoms of scurvy. A cent study from England (*5*) on long-time deprivation of the vitamin humans demonstrated that an intake of as little as 10 mg of ascorbic id each day was sufficient to relieve the clinical symptoms of scurvy. view of these observations, it is easy to see why mild scurvy might e hard to detect.

ecommended Allowances for ascorbic acid

The Recommended Allowances for ascorbic acid are considerably gher in this country than in England. A daily allowance of 30 g has been recommended for the English people in view of the port that the clinical symptoms of scurvy were relieved when mg of the vitamin was ingested. In spite of this suggestion, ere is adequate evidence that higher intakes of ascorbic acid are eneficial to individuals of all ages.

The daily dietary allowances of the National Research Council re 100 mg and 80 mg, respectively for college men and women etween the ages of 16 and 19 years. Beyond 19 years of age, it has

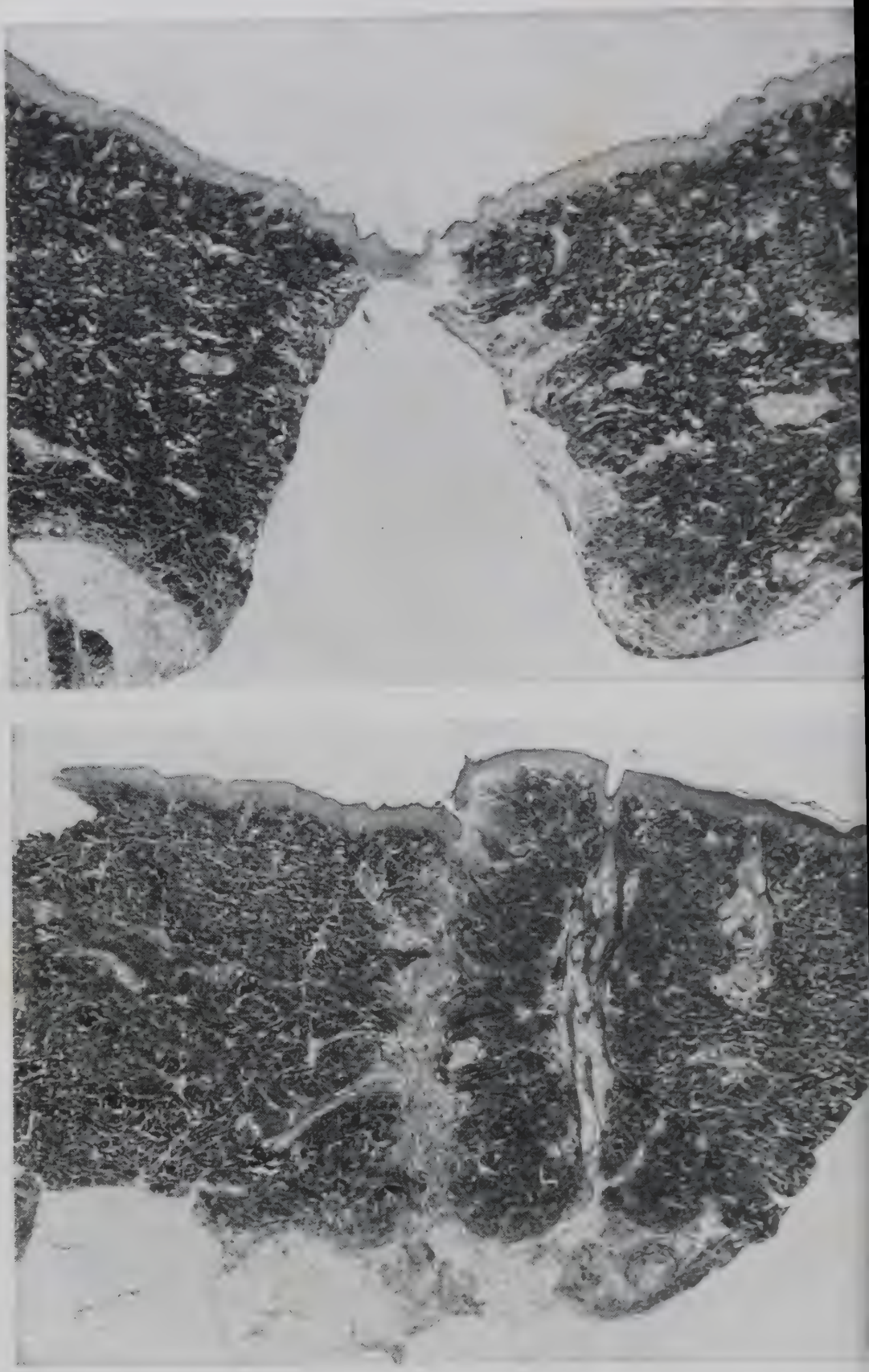


Fig. 68. The first satisfactorily controlled experiment in human scurvy was conducted when J. H. Crandon placed himself on an ascorbic acid-free diet, sup-

en suggested that men of all ages should ingest 75 mg of the amin each day and women only 70 mg. During growth, pregncy, and lactation, however, the recommended amount of the tamin varies.

ood sources of ascorbic acid

Fruits and vegetables are the main sources of ascorbic acid in ets. Citrus fruits (oranges, grapefruit, lemons, and limes), berries, elons, tropical fruits (pineapple, guava, and others), green leafy getables, broccoli, green pepper, cabbage, and tomatoes are all ood sources of ascorbic acid (Table 26). The large amounts of otatoes used in low-income diets make this vegetable an important corbic acid food for many people.

The best natural sources of ascorbic acid have been found in the se hip and the acerola fruit (the West Indian cherry). Rose hips, hich constitute the base of the rose bloom, are not eaten as such, ut in some countries are made into a syrup or extract for human onsumption. During the wartime rationing of food in England, rose ip syrup was issued by the British Ministry of Food to help fortify he ascorbic acid intake of the English people. There is much inerest today in the acerola fruit because of its high ascorbic acid ontent. Scientists have reported that the ascorbic acid potency of his tropical cherry juice may be as much as 30 to 80 times that of an qual amount of orange juice. At the present time the acerola fruit being used commercially to fortify low ascorbic acid fruit juice i.e., apple juice, apricot juice) for use in child feeding.

Many of the values that are listed in food tables for the ascorbic cid content of foods are based only on reduced ascorbic acid neasurements. Because of the newer knowledge of our ability to se dehydroascorbic acid, there is a need to revise food table values for scorbic acid in order to include the total ascorbic acid contribution f a food. From a figure listing both the reduced and total vitamin alues of commonly used foods (Fig. 69), one can readily see the lightly higher ascorbic acid values in the bars indicated as total. uch foods as frozen asparagus, canned orange juice, as well as

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lemented by all other known vitamins, for six months. After six months on the corbutic diet a wound was made in the midback region. (Top.) Biopsy 10 ays after wound shows no healing except of the epithelium (gap in tissue was lled with blood clot). (Bottom.) After 10 days of ascorbic acid treatment nother biopsy of the wound shows healing with abundant collagen formation. Courtesy J. H. Crandon and The Upjohn Company.)

Table 26. Ascorbic Acid Values of Some Typical Foods

Food	Measure	Ascorbic Acid, mg
Guava	1 raw (80 gm)	212
Lemon juice	1 cup, fresh	122
Orange juice	1 cup, fresh	122
Grapefruit juice	1 cup, canned	85
Green pepper	1 medium, raw (76 gm)	77
Orange	1 medium	77
Grapefruit	½ medium	76
Broccoli	⅔ cup, cooked	74
Lime juice	1 cup, fresh	65
Strawberries	⅔ cup, raw	59
Turnip greens	⅔ cup, cooked	58
Cantaloupe	1 cup, diced	47
Mustard greens	⅔ cup, cooked	42
Brussels sprouts	⅔ cup, cooked	41
Tomato juice	1 cup, canned	38
Kale	⅔ cup, cooked	37
Spinach	⅔ cup, cooked	36
Tomato	1 medium, rare	35
Coleslaw	⅔ cup	33
Sweet potato	1 medium, baked	28
Cabbage	⅔ cup, cooked	21
Pineapple	½ cup, raw	17
Beef liver	2 oz, cooked	18
Potato	1 medium, baked	17
Black raspberries	½ cup, raw	16
Green peas	⅔ cup, cooked	16
Milk	1 cup, whole	3
Butter	1 pat	0
Egg	1 whole	0
Ground beef	3 oz, cooked	0
Sugar	1 teaspoon	0
White bread	1 slice	0

From *Composition of Foods—Raw, Processed, Prepared.* U.S. Department of Agriculture, Agriculture Handbook 8, 1950.

homogenized, pasteurized milk show marked differences between the reduced and total vitamin content. A quart of milk, in view of this information, contributes approximately 12 mg of potential ascorbic acid rather than just 4 mg and therefore may supply an appreciable amount of the vitamin to the diet.

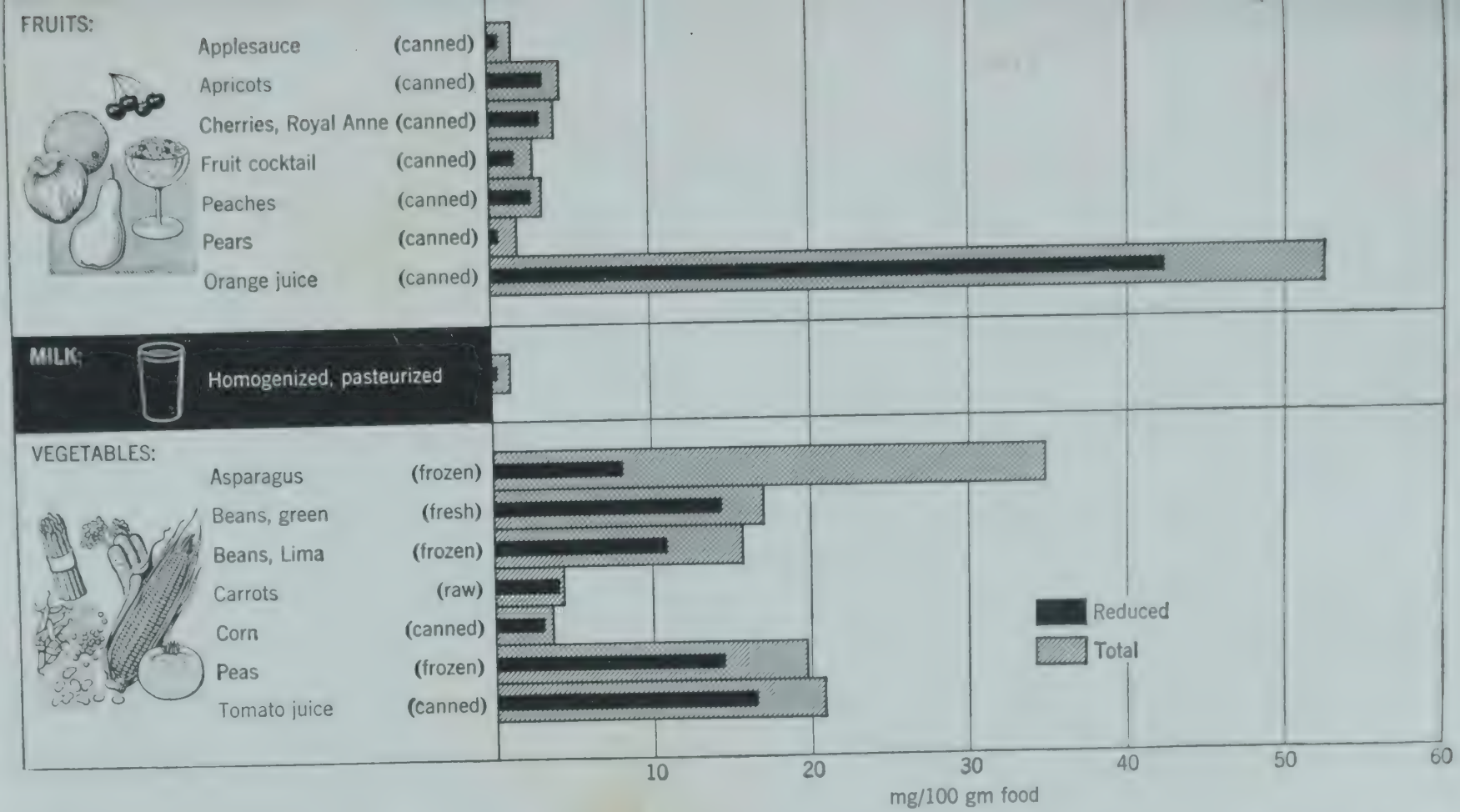


Fig. 69. Average values of reduced and total ascorbic acid of some commonly used foods. (Adapted from Fisher and Dodds, *Food Res.* **20**: 247, 1955.)

Ascorbic acid losses during the processing and preparation of foods

It is known that a food may lose much of its original ascorbic acid from the time it is harvested until it is eaten because of the many stages of processing and storage it may undergo. Because ascorbic acid is soluble in water and in solution is so easily destroyed by other factors, it has come to be known as the most *labile* or easily destroyed of the vitamins. Therefore, in order for one to prepare and serve foods which are acceptable as well as nutritious, it is important to know how this vitamin may be conserved.

The environment in which a plant food is grown may have a significant effect upon its ascorbic acid content. Temperature, amount of rainfall, type of soil, and sunlight appear to be factors directly related to the formation of plant ascorbic acid. In addition to these factors, the stage of maturity at which a food is harvested is important in order to obtain the maximum amount of this nutrient. For example, immature Lima beans and white potatoes contain more ascorbic acid than do mature ones, whereas ripe tomatoes have a much higher vitamin content than do green ones.

The effect of food preservation. The manner in which a food is preserved, by freezing, by canning, or by drying (dehydration) has a significant effect on its ascorbic acid content. This fact can be well illustrated by comparing the vitamin values of fresh, frozen, canned, and dried Lima beans, all commonly used foods in the American diet. An edible portion of Lima beans weighing 100 gm has an average ascorbic acid value of 32 mg in the raw form, 17 mg when frozen, 6 mg when canned, and 2 mg when dried.

Students often ask if the amount of ascorbic acid in orange juice is in any way affected by the kind of processing it undergoes. This question can best be answered by the report of a study made at the University of Illinois where they compared the reduced ascorbic acid values as well as the cost of an average serving of fresh, frozen concentrated, canned concentrated, and canned juices from oranges. All of the orange juice analyzed in this work, regardless of processing procedures, was quite similar in ascorbic acid content, but the frozen concentrate cost less per average serving at the time of that investigation than did either the fresh or the canned.

The effect of storage. Two other factors that are important in conserving the ascorbic acid content of a food are the time interval between the processing and consumption of a food as well as the kind of storage facilities available. From the University of Massachusetts it has been reported that pasteurized milk loses about two-

thirds of the reduced ascorbic acid content after 4 days under refrigeration. However, if the milk was consumed within the first day after processing, about 80 per cent of the original reduced ascorbic acid would have been available. Orange juice and other citrus juices lose negligible amounts of ascorbic acid when stored in the refrigerator; the acid of the juice helps to preserve the vitamin.

The vitamin content of frozen fruits and vegetables has been observed to be affected by changes in storage time and storage temperature. Frozen cherries, peaches, and strawberries were found, by a group at the Pennsylvania State University, to have lost marked amounts of ascorbic acid when stored longer than 4 months at +10° F. However, when the same fruits were stored at a lower temperature, 0° F to −20° F, there was no appreciable loss of the vitamin within the same period of time. Asparagus, green beans, wax beans, broccoli, cauliflower, corn, and spinach stored at +10° F lost 50 per cent of the reduced ascorbic acid content after 4 months storage, but when stored at 0° F most of the vitamin was retained. It is evident from this work that both frozen fruits and vegetables conserve the ascorbic acid value best by storage at lower temperatures.

Canned foods are also subject to marked losses in ascorbic acid when stored at elevated temperatures for long periods of time. Canned tomato juice, after 8 months of storage, has been shown to retain only about one-half of the reduced ascorbic acid content when held at room temperature (68° to 77° F.) and only about one-third when the temperature was increased to 99° F.

The effect of food preparation. The amount of ascorbic acid in a food to be eaten is directly related to the kind of food preparation practices used. A raw food that one eats will have more of the vitamin than will one that has been cooked or baked. The removal of the natural skin of a vegetable will increase the loss of the vitamin from the food due to the leaching of the nutrient into the soaking or cooking water. Further losses of the vitamin will occur when a peeled vegetable is subdivided into smaller sections, i.e., diced potatoes, because the surface area exposed to the soaking or cooking water is increased. The use of copper cooking utensils will decrease the ascorbic acid content in a food because of the destructive nature of the copper ion to the vitamin.

The method used in cooking a food will determine the amount of ascorbic acid retained by it. In order to illustrate the amounts of the vitamin that may be lost in vegetable cookery, data from Yale University have been adapted to show the retention of reduced ascorbic acid in fresh green peas cooked by three commonly used

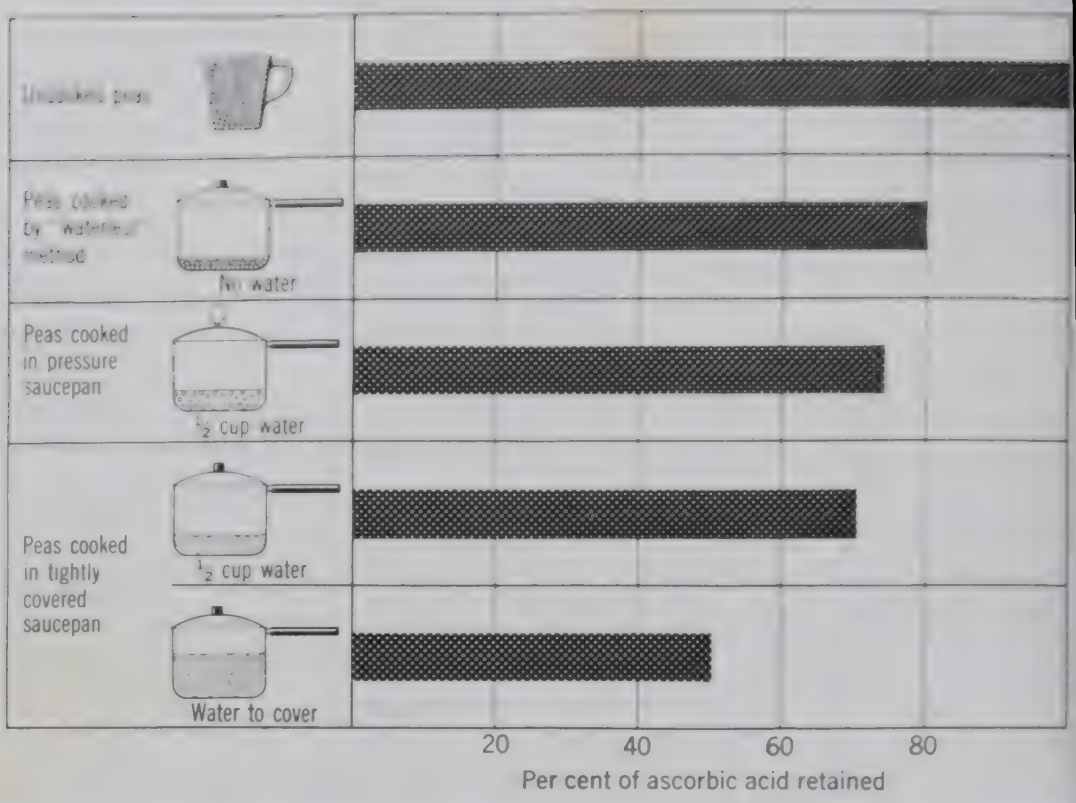


Fig. 70. The reduced ascorbic acid content of green peas as affected by three widely used home cooking practices. (Adapted from Krehl and Winters, *J. Am. Dietet. A.* **26**: 966, 1950.)

home cooking methods (Fig. 70). The peas retained more of the vitamin when cooked in the waterless cooker or in the pressure saucepan than when cooked in the tightly covered saucepan. In the tightly covered saucepan method, reducing the amount of water used from enough water to cover the vegetables to only one-half cup increased by about one-third the amount of ascorbic acid in the cooked peas.

A guide to the selection of foods to meet the ascorbic acid needs of college men and women

Surveys from many areas of the United States have shown that ascorbic acid is one of the nutrients most often found to be deficient in the diets of college men and women. Because of the important role of this vitamin in the maintenance of good health and the fact that it is one of the nutrients ingested in suboptimal amounts, it is important that you know the approximate contribution of the foods eaten in relation to your daily needs.

Servings of some commonly used ascorbic acid-rich foods have been classified into groups representing three-fourths, one-half, one-fourth, and one-eighth of a college student's need for the vitamin. Because the daily ascorbic acid standard for college men between the ages of 16 and 19 (100 mg) is somewhat higher than that for college women of the same age (80 mg), two different sets of values are presented (Fig. 71). Using this scheme, a college woman 19 years old, who had one-half grapefruit for breakfast ($\frac{1}{2}$), 1 cup of tomato soup at lunch ($\frac{1}{2}$), and 1 quart of milk ($\frac{1}{8}$) throughout the meals of the day, can easily find her total daily intake of ascorbic acid to be more than adequate ($1\frac{1}{8}$).

Amount of Food (College Men 16–19 years)	Approximate Fraction	Amount of Food (College Women 16–19 years)
¾ cup grapefruit juice 1 cup grapefruit sections 1 medium orange 5 ounces orange juice		⅔ cup grapefruit juice ¾ cup grapefruit sections 1 small orange 4 ounces orange juice
½ cup broccoli 1 cup coleslaw ¾ green pepper		⅓ cup broccoli ¾ cup coleslaw ½ green pepper
1¼ cups pineapple juice ½ cup cooked spinach ⅔ cup tomato juice		1 cup pineapple juice ⅓ cup cooked spinach ½ cup tomato juice
1¼ quarts whole milk 1 cup mashed potatoes ⅔ cup green beans 1¼ cups canned peaches		1 quart whole milk ¾ cup mashed potatoes ½ cup green beans 1 cup canned peaches

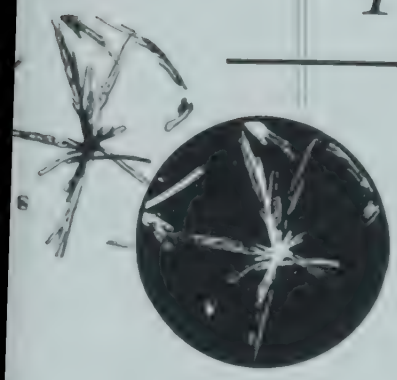
Fig. 71. The amount of an individual food needed to provide a certain fraction of the day's Recommended Allowance of ascorbic acid for college men and women.

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CHAPTER 15

The B-complex vitamins



I. THIAMINE, RIBOFLAVIN, AND NIACIN

The B-complex vitamins are a group of related nutrients that are important for the well-being of every cell in the body. Because these factors are a part of the human enzyme systems, they are essential for the normal metabolism of the food one eats. When any of these vitamins are missing, in an otherwise adequate diet, characteristic deficiency symptoms are produced in both man and animals. At this time, the ten vitamins included in the B-complex family are thiamine, riboflavin, niacin, vitamin B_6, pantothenic acid, biotin, folacin, vitamin B_{12}, choline, and inositol. The first three of these vitamins are discussed in this chapter, the other seven are presented in the following chapter.

Thiamine

Beriberi, a nervous system disease that is caused by a lack of thiamine in the diet, has occurred in the Far East for centuries and has resulted in a high morbidity and mortality rate among the peoples of these countries. Not until 1882 was it shown by Takaki, at that time Director-General of the Medical Department of the Japanese Navy,

that beriberi could be prevented in man by the intake of a good die
A decade later the observations of Eijkman, a Dutch medical scienti
in Java, initiated the research that finally led to the identification o
thiamine as the anti-beriberi vitamin. Eijkman noted that the chicken
housed in the hospital yard near his laboratory developed a disorde
similar to human beriberi when fed a ration solely of polished rice
Because of the general paralysis and head retractions which occurre
in the birds, he called this disease *polyneuritis* (inflammation of many
nerves). He found that the symptoms of the polyneuritis disappeared
when rice polishings (the outer layers and embryo of the rice kernel
were fed to the birds. In 1911, Funk (the Polish biochemist) pre
pared a small amount of a crystalline material from a rice bran ex
tract which he found cured experimental beriberi in birds. Becaus
he called this substance *beriberi vitamine*, he is credited with coining
the word vitamin. Four years later, McCollum confirmed the
existence of a single substance which not only cured polyneuritis bu
also promoted growth and he named this factor, *water-soluble B*
Jansen and Donath, at Eijkman's laboratory in Java, demonstrated
the vitamin's curative effect in human beriberi in 1926, after they had
prepared sufficient crystals of the vitamin from rice bran. Ten years
later, R. R. Williams and his group in this country identified the
chemical structure of thiamine and then developed the first method
for its synthesis.

Properties of thiamine

Although the term, *vitamin* B_1, has been used for many years to
identify this factor, thiamine is now the official accepted name for the
vitamin in the United States. The colorless crystals of the vitamin
(Fig. 72), which have a yeastlike smell and a salty taste, are very
soluble in water. Thiamine is quite stable in acid solutions, but in a
neutral or slightly alkaline solution it is easily destroyed by heat.
Commercially, the vitamin is sold in the form of thiamine hydro-
chloride.

Function of thiamine

Thiamine is important to the body as one of the keys in the release
of energy during the metabolism of carbohydrates where, as thiamine
pyrophosphate (cocarboxylase), it functions in the enzyme system.
Carbohydrate metabolism may proceed to the formation of pyruvic
acid, an intermediate compound; thiamine is essential for the orderly
breakdown of pyruvic acid. It is believed that the enzyme systems

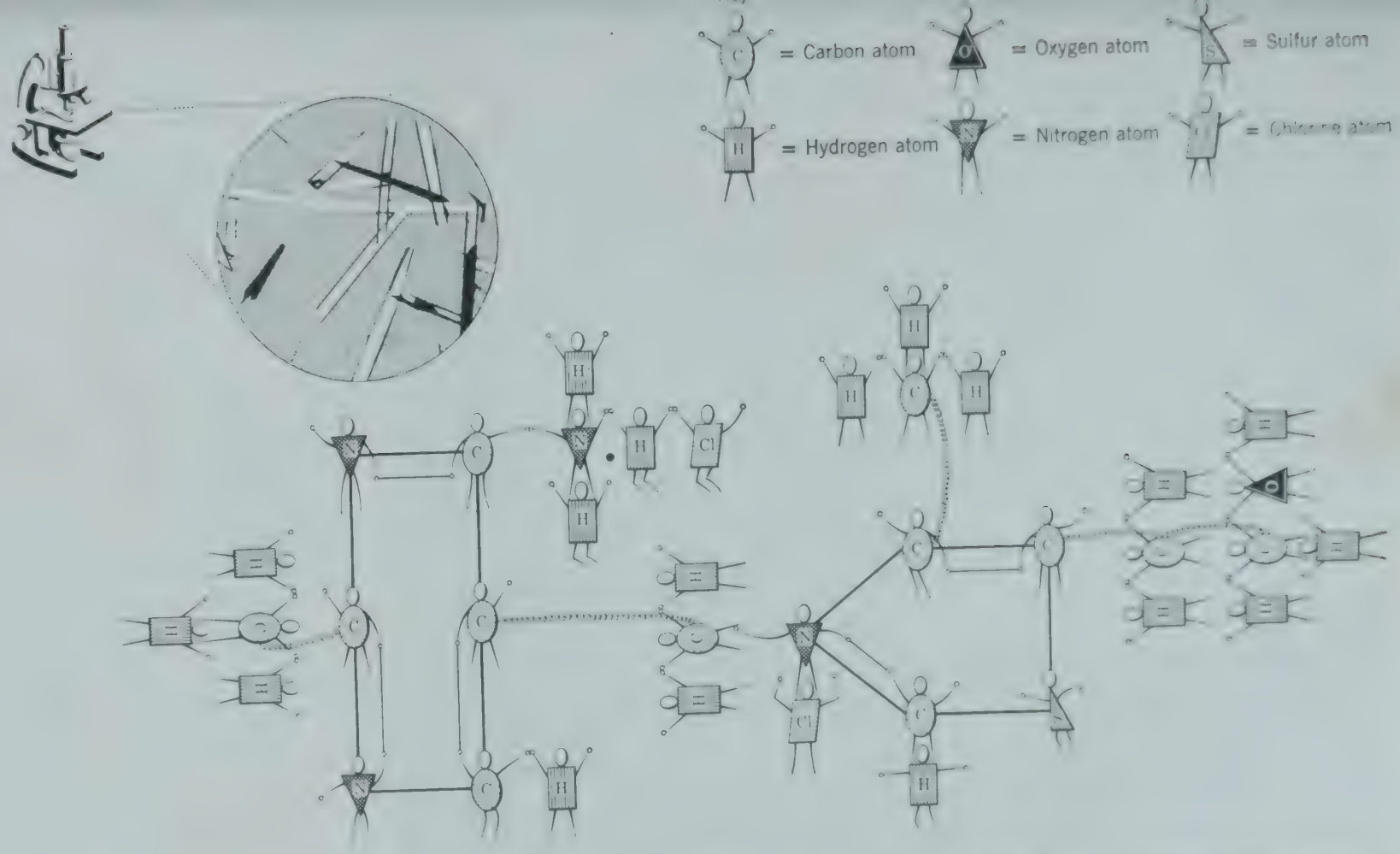


Fig. 72. Crystalline thiamine and a diagrammatic representation of its chemical formula. (Photomicrograph courtesy Merck and Co., Rahway, N.J.)

containing the vitamins of the B-complex family, along with other vitamins and certain minerals, work cooperatively in the utilization and storage of energy and in the normal functioning of body processes that involve growth and body maintenance.

Thiamine appears to have several indirect functions in the body because of its role in energy metabolism. The maintenance of the appetite, the tone of the muscles, and a healthy mental attitude are all related to thiamine nutrition.

One of the earliest symptoms of a thiamine deficiency in man is the loss of appetite or *anorexia*. In several human studies involving thiamine deprivation (*11*, *12*, *15*), anorexia was observed as early as the fourth day and became so severe as the deficiency progressed that the subjects had to force themselves to eat food. With the restoration of the vitamin to the diet, however, the loss of appetite disappeared very quickly. Indirectly, thiamine will promote growth because the stimulation of the appetite results in an increased consumption of food.

Constipation and tenderness of the muscles of the leg calf are two symptoms frequently found in experimental thiamine deficiencies. The sluggishness of the intestinal muscles associated with constipation may be a result of insufficient thiamine in the diet. Very soon after the vitamin is restored to the food intake after periods of thiamine deprivation subjects have reported relief from both of these symptoms.

Thiamine is often called the *morale* vitamin because of its ability to restore a healthy mental state in man following periods of experimental deprivation. When human subjects are fed restricted amounts of thiamine in their diets, changes in the emotional stability of normal subjects have been observed. Williams (*15*) found that his subjects on restricted intakes of thiamine became irritable, quarrelsome, and moody; they failed to cooperate; and at times they suffered periods of mental depression. Although thiamine is not beneficial in the treatment of mental disorders, it has been observed that dietary restriction of the vitamin in mental patients appears to intensify the psychiatric symptoms of their mental state (*10*). The interest, ambition, attention, and sociability of these patients has been observed to be definitely affected by suboptimal intakes of the vitamin as shown by a decrease in talking and a slowing of body movement.

The effects of a thiamine deficiency

In animals. All species of animals need thiamine for normal energy metabolism. Although the ruminants (cattle and sheep) are able to synthesize adequate amounts of the vitamin in their rumens, other



Fig. 73. Thiamine-deficient rat (above) shows the typical arched back and hyperextended hind legs. Such rats have a spastic gait, turn awkwardly, and lose balance. When rotated, they regain equilibrium with difficulty. Below, the same rat 8 hours after receiving thiamine hydrochloride has normal use of its hind legs. (Courtesy of The Upjohn Company.)

animals must obtain a supply of thiamine in their daily food ration in order to meet their needs.

Regardless of species, the symptoms of a thiamine deficiency in animals are quite similar. It is believed that the symptoms are related to the disturbances in carbohydrate metabolism accompanying thiamine deficiency, although the precise relationship is not known as yet. The albino rat, which may be used in the classroom to demonstrate

the effects of this vitamin deficiency, develops anorexia and soo
begins to lose weight when fed a ration low in thiamine. As th
deficiency progresses, the animal develops a spastic gait, due to
partial paralysis caused by affectation of the nerves; shows signs of
slowing of the heartbeat; regains its equilibrium with much difficul
after being rotated; and suffers from convulsions. The condition
known as polyneuritis. It is interesting to observe the dramat
recovery of these thiamine-deficient rats within eight hours aft
receiving supplements of the vitamin (Fig. 73).

In man. Beriberi is the name of the disorder in man that resul
from a severe deficiency of thiamine. Although beriberi occurs ver
rarely in the Western countries, it is a common disease in the countri
of the world where polished rice is the main item of the diet. Durin
1947 beriberi ranked second as the cause of death among the peop
of the Philippine Islands.

The three general symptoms of beriberi are polyneuritis, eithe
edema or emaciation of the body tissues, and disturbances of th



(*a*) (*b*)

Fig. 74. The foot drop of beriberi. (*a*) Patient with peripheral neuritis of nu
tritional origin shows limit of flexion of ankles. (*b*) Moderate flexion is possibl
after 2½ weeks of thiamine therapy. (Courtesy H. Field, Jr., and the Upjoh
Company.)

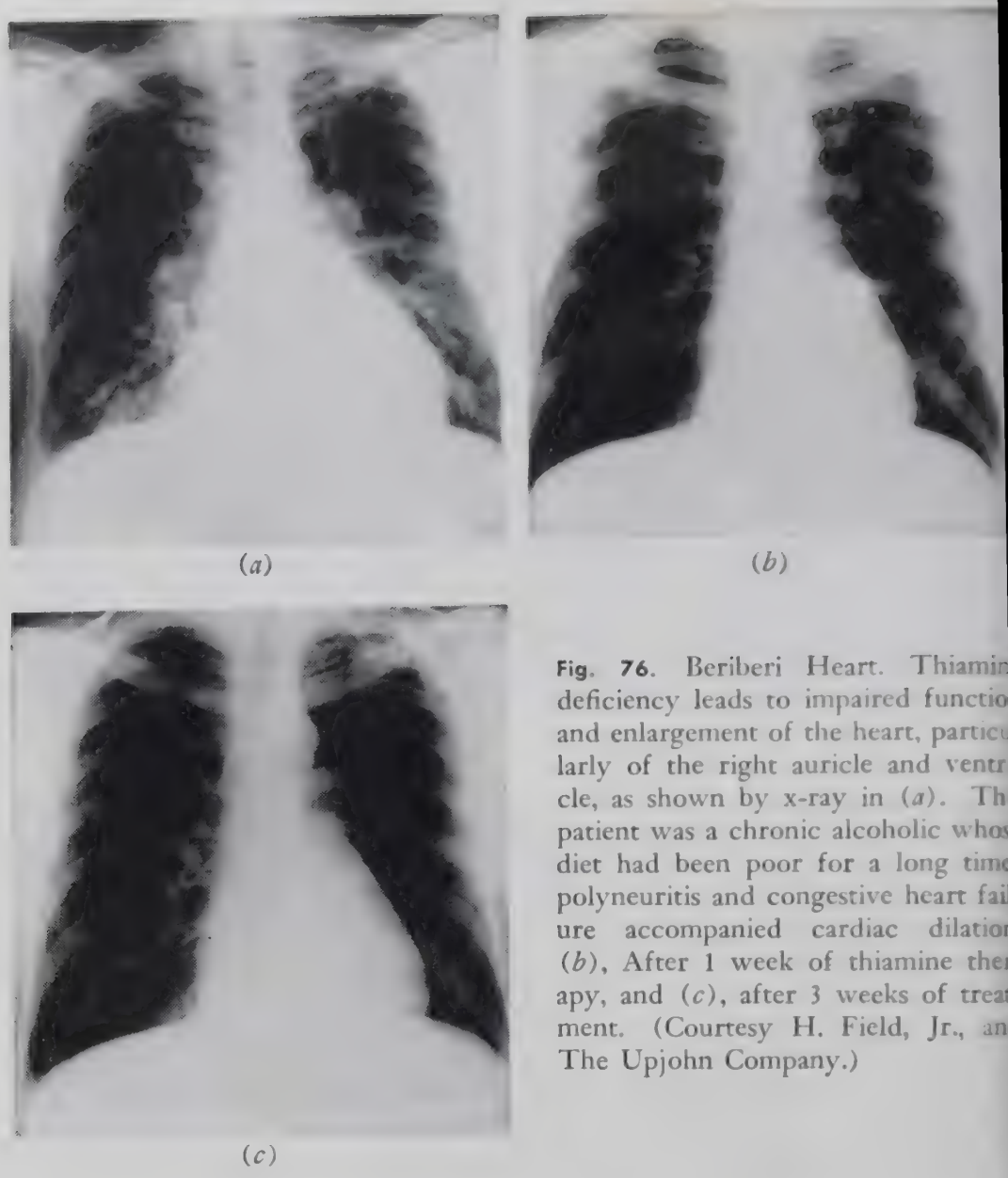


(*a*) (*b*)

ig. 75. Pitting Edema. (*a*) Swelling of legs with pitting in ankle region marks eginning of so-called wet beriberi. (*b*) Same patient is shown four days after single intravenous injection of 50 mg. thiamine. During this period the patient's xcretion of fluid exceeded intake by 10½ lbs. (Courtesy of Spies, Hillman Hospital, Birmingham, Alabama, and the Upjohn Company.)

eart. The polyneuritis begins with a soreness in the muscles of the egs and is soon followed by a decrease in the reflex of the knee nd a drop in the muscles that support the toes and foot. This latter ymptom of the disorder accounts for the high-stepping gait observed n beriberi patients (Fig. 74). As the disorder advances, however, the rms and other parts of the body become affected because of a legeneration and lack of coordination of the body muscles. When edema occurs in beriberi, the body tissues become swollen because of he accumulation of fluid in the body cells (Fig. 75). This condiion is referred to as *wet beriberi* and is noticed first in the legs and highs of the patient. Sometimes there is a reverse condition in which edema does not occur but rather emaciation exists, this is diagnosed s *dry beriberi*. Inasmuch as the beriberi sufferer breathes with great difficulty and his heart beats rapidly and becomes enlarged (Fig. 76). Death in beriberi is due to these cardiac impairments.

It is quite possible that cases of mild thiamine deficiency do occur



(*a*) (*b*)

(*c*)

Fig. 76. Beriberi Heart. Thiamin deficiency leads to impaired functio and enlargement of the heart, particu larly of the right auricle and ventr cle, as shown by x-ray in (*a*). Th patient was a chronic alcoholic whos diet had been poor for a long time polyneuritis and congestive heart fail ure accompanied cardiac dilation (*b*), After 1 week of thiamine ther apy, and (*c*), after 3 weeks of treat ment. (Courtesy H. Field, Jr., and The Upjohn Company.)

often in this country although cases of extreme deprivation of the vitamin are rare. Suboptimal intakes of this vitamin have been reported to exist among people of all age groups as shown by nutrition surveys from various parts of the United States. From human studies of the effects of mild thiamine deprivation in the diet one is able to recognize some of the typical symptoms which accompany subclinical cases. Fatigue, anorexia, constipation, labored breathing, lassitude (weariness), nausea, tenderness of the leg calf, depression, changes in the electrocardiogram measurement, low excretion of thiamine in the urine, and an increase of pyruvic acid in the blood are the symptoms which accompany a thiamine deficiency. Although

me of these symptoms are specific for thiamine, others may result m other nutrient deficiencies.

commended Allowances for thiamine

The human requirement for thiamine is based on the total Calories the diet. Although normal, healthy adults appear to have a inimum requirement of about 0.23 mg per 1000 Cal. of food intake, e suggested allowances of the National Research Council have pro- ded for about 100 per cent safety factor of thiamine in the diet cause of the varying needs of individuals and the lack of large body ores of the vitamin. Regardless of age, an allowance of 0.5 mg r 1000 Cal. for caloric intakes of less than 3000 and 0.2 mg for each ditional 1000 Cal. above this level have been used in calculating iamine needs.

College men 16 to 19 years of age and young male adults over 19 ears need 1.8 mg and 1.6 mg of thiamine, respectively, each day. slightly lower allowance, 1.2 mg per day, has been proposed for the ollege and young adult women of the same age range. In the stress eriods of life (growth, pregnancy, and lactation), the thiamine eed is increased. As one grows older, though, the need for the itamin decreases in proportion to the decrease in caloric require- ent.

ood sources of thiamine

All the foods of the diet with the exception of fats, oils, and refined ugars contain some thiamine. However, there are no foods par- cularly high in thiamine content as there are for ascorbic acid and itamin A.

Although brewer's yeast and wheat germ head the list of the hiamine-containing foods (Table 27), they are not very important in he typical food intake because relatively few people eat either one f these in large amounts. The best sources of the vitamin in the verage diet are pork products, legumes, and whole grain and enriched ereals. Nuts vary in their thiamine content but when they are sed in large amounts, prove to be rich contributors of the vitamin. The thiamine in the egg is confined to the yolk. The use of a quart f milk each day will contribute a good share toward filling one's hiamine need.

hiamine losses during food processing and preparation

Vegetables. The amount of thiamine retained in a vegetable during reezing or canning is apparently related to the nature of the food

Table 27. Thiamine Values of Some Typical Foods

Food	mg/100 gm	Portion	mg/servi
Dried brewer's yeast	9.69	1 tbsp	0.78
Wheat germ	2.05	1 cup	1.39
Ham, boiled	1.01	3 oz	0.86
Brazil nuts, shelled	0.86	½ cup	0.61
Pecan nuts, shelled	0.72	½ cup	0.39
Bran flakes, 40 per cent	0.46	1 cup	0.19
Graham crackers	0.30	2 medium	0.04
Bread, whole wheat	0.30	1 slice	0.07
Egg yolk	0.27	1 medium	0.05
Green peas, fresh, cooked	0.25	⅔ cup	0.27
Bread, white, enriched	0.24	1 slice	0.06
Lima beans, fresh, cooked	0.14	⅔ cup	0.15
Green peas, canned, drained solids	0.12	⅔ cup	0.13
Peanut butter	0.12	1 tbsp	0.02
Ground beef, cooked	0.08	3 oz	0.07
Orange juice, fresh	0.08	1 cup	0.19
Bread, white, unenriched	0.05	1 slice	0.01
Milk, whole	0.04	1 cup	0.09
Lima beans, canned, drained solids	0.04	⅔ cup	0.03
Rice, white unenriched, cooked	0.01	⅔ cup	0.01
Sugar, white	0.0	1 tsp	0.0
Butter	0.0	1 tbsp	0.0

From *Composition of Foods—Raw, Processed, Prepared.* U.S. Department o Agriculture, Agriculture Handbook 8, 1950.

used. Peas have shown no significant loss of the vitamin during th freezing procedures but spinach and asparagus have been reported t lose about 51 per cent and 28 per cent, respectively, of their origina content. In a study to determine the effect of canning procedure on the vitamin retention of vegetables, it was concluded that th thiamine retention was excellent in tomatoes, good in tomato juice only fair in asparagus, and relatively poor in snapbeans, Lima bean corn, peas, and spinach.

Under ordinary conditions of home cooking, most of the thiamin lost in a food is due to the leaching of the vitamin into the cookin water rather than to heat destruction. This fact was observed whe twelve different vegetables were processed in family-size amount by four different cooking methods. The average retention of thiamin in all the vegetables averaged 91.0 per cent (waterless cooker), 84. per cent (tightly covered saucepan with ½ cup water), 78.9 per cen

pressure cooker), and 62.6 per cent (tightly covered saucepan with ater to cover). In view of this report, it appears that the thiamine ontent of a vegetable can be conserved if it is cooked in the least nount of water compatible with good palatability.

Because thiamine is highly soluble in water, the liquid fraction of a anned vegetable as well as the soaking or cooking water from a egetable will contain an appreciable amount of the vitamin lost from he vegetable solid during processing or food preparation. In order o utilize all the thiamine contained in the foods of the diet, this liquid raction should be used and not discarded.

Meats. Because pork and its products are excellent sources of hiamine in the American diets, it is important to know the effect that ooking methods have on the retention of the vitamin in these foods.

Studies have been made on the retention of the vitamin in fresh ams and pork loins, fresh ground pork, as well as in cured hams efore and after cooking by standardized procedures. Although the hiamine content of different cuts from the same pork loin or ham nay vary considerably, the retention of the nutrient after cooking is uite uniform. Pork loins and fresh hams have been shown to retain bout 70 per cent of their thiamine after roasting and broiling and bout 50 per cent after braising. When the vitamin content of the rippings from these pork products is added to the thiamine value of he cooked meat, there is about 70 per cent retention for all three nethods of preparation. As much as 85 per cent of the vitamin was etained in ground pork patties when they were cooked by pan-roiling, oven-broiling, or dielectric cookery. In the curing of ham, lmost three-fourths of the original thiamine of the fresh meat has been reported to be retained. Fried cured ham has a higher thiamine ontent than cured ham that has been roasted, braised, or broiled. Regardless of the processing procedure or the method of cookery, it ppears that cooked pork products are worthwhile contributors of hiamine to the diets.

A guide to the selection of foods to meet the thiamine need of college men and women

Servings of commonly used thiamine-rich foods have been classified nto groups representing fractions of a college student's need for this itamin. Two sets of values are represented in Fig. 77 because of he difference in the need for thiamine between 16 to 19 year old ollege men (1.8 mg) and college women (1.2 mg). From this table, one can find that 4 oz of boiled ham at dinner and one quart of milk s well as 4 slices of white enriched bread throughout the meals of the

Amount of Food (College Men 16–19 years)	Approximate Fraction	Amount of Food (College Women 16–19 years)
		
6 ounces ham		4 ounces ham
1¼ quarts whole milk		¼ quart whole milk
4½ slices enriched white bread 1¼ cups Lima beans 11½ ounces ground beef 1¼ cups oatmeal		3 slices enriched white bread ¾ cup Lima beans 6 ounces ground beef ¾ cup oatmeal

Fig. 77. The amount of an individual food needed to provide a certain fracti of the day's Recommended Allowance of thiamine for college men and wome

day would furnish seven-eighths of the thiamine need of a youn college man.

Riboflavin

As early as 1920, some workers began to question the belief tha *water-soluble B* was a single nutritive factor. Studies had shown tha after a food containing this dietary essential had been autoclaved, still had the ability to promote growth in animals even though i antineuritic powers were destroyed. This observation indicated tha the water-soluble B was not a single factor but rather a mixture factors, one that was destroyed by heat and the other that heat di not affect. About 1928, the fact had definitely been established tha there were at least two different vitamins contained in this comple an antineuritic factor (vitamin B_1, now called thiamine) and a growth promoting factor (vitamin G or B_2, now called riboflavin).

The first steps in the isolation of riboflavin began in Germany out 1930 when a yellowish-green fluorescent material, which mulated growth in animals, was isolated from egg white. Soon it s found that similar fluorescent substances were present in milk, er, yeast, muscle, and certain plant materials. The fluorescent ma- nals all proved to belong to a chemical family called the *flavins* and were named after the foodstuff from which they were isolated, ch as *ovoflavin* from egg and *lactoflavin* from milk. Later, chemical udies showed that all of these fluorescent materials were identical th one another and the name, riboflavin, was the general term lopted to identify them. Riboflavin has been produced synthetically nce 1935.

roperties of riboflavin

Riboflavin occurs in yellow-orange crystals (Fig. 78), which are nly slightly soluble in water; solutions of the vitamin have a yellow- h-green fluorescence. The presence of acids, air, or heat have no estructive effect upon the vitamin, but riboflavin is easily destroyed y alkalies and light.

unction of riboflavin

Like thiamine, riboflavin serves as a coenzyme in several of the nzyme systems of the body that are involved in the metabolism of the nergy nutrients.

he effects of a riboflavin deficiency

In animals. Because the rat was used as the experimental animal in he early studies of this vitamin, there is available a wealth of in- ormation on the effect of a riboflavin deficiency in this species. Growth failure, which occurs even though the animal is ingesting a ufficient quantity of food, is one of the early symptoms of ribo- avin deprivation in the rat. Soon changes in the condition of the kin and eyes become apparent. At first there is *alopecia* around the ose and on the paws, and then a *dermatitis* develops in these areas Fig. 79). The eye lesions in a riboflavin deficient rat vary in severity nd may range from *conjunctivitis* to the formation of a permanent ataract. Digestive and nervous disturbances are also observed as the eficiency becomes more pronounced, and death will occur if the itamin is not restored to the animal's ration. All animals need ribo- avin for normal growth and body maintenance.

In man. Riboflavin deficiency in man may be complicated by a eficiency of other vitamins of the B-complex family and for this

Fig. 78. Crystalline riboflavin and a diagrammatic representation of its chemical formula. (Photograph courtesy



(*a*)



(*b*)

g. 79. Generalized dermatitis and growth failure in riboflavin-deficient rat (*a*). fter two months of treatment with riboflavin, the rat shows no signs of the riginal deficiency (*b*). (Courtesy The Upjohn Company.)

reason the clinical symptoms of human riboflavin deprivation are n
as clear-cut as were those of thiamine. The first experimentally
duced riboflavin deficiency in man was reported in 1938 by Sebr
and Butler (*14*). They found that the women subjects of their stu
developed *cheilosis*, a reddening of the mucous membranes of the li
and *seborrhea*. All of these lesions disappeared when riboflavin w
restored to the diet. In a more recent study of induced human *arib
flavinosis* (*9*), the same kind of skin lesions were found to devel
in the male subjects maintained on suboptimal intakes of the vitam
for a period of 9 to 17 months. The changes in the tissues of t
eyes due to riboflavin deprivation in humans are not as specific as r
lesions of the skin. It is believed that *conjunctivitis* as well as *lacrim
tion* (a watering of the eye) are the ocular lesions which can
attributed to human ariboflavinosis. The condition involving t
vascularization of the cornea where the capillaries invade the corn
tissue has not been proven as yet to be a specific lesion of riboflav
insufficiency in man.

Recommended Allowances for riboflavin

The need for riboflavin is related to body weight as is the prote
need. For this reason, the amounts of the vitamin recommended b
the National Research Council are calculated from the protein allow
ances using the factor 0.025.

The daily riboflavin needs of college men and women between th
ages of 16 and 19 years have been suggested to be 2.5 mg and 1.9 m
respectively. Over 19 years of age, all men, regardless of age, nee
about 1.8 mg of the vitamin each day and 1.5 mg has been recom
mended for all women. Here again, the need for this vitamin is in
creased during growth, pregnancy, or lactation.

Food sources of riboflavin

Because the best food sources of riboflavin, brewer's yeast an
glandular meats, are not used to any great extent in an average die
their value as dietary contributors is not very significant (Table 28
However, because it is so widely used as a dietary food, milk is prob
ably the chief source of the vitamin in most American diets. Th
ingestion of one quart of whole milk per day contributes approx
mately 1.68 mg of the nutrient which is about 67 per cent and 88 pe
cent, respectively, of the daily riboflavin requirement of college me
and women under 20 years of age. Cheese, eggs, veal, beef, gree
leafy vegetables, and salmon are other foods that are good source
of the vitamin. In addition, the use of whole grain or enriche

cal products rather than those that are unenriched will bolster the ount of the vitamin ingested. Students often wonder why a 100 portion of whole-wheat bread (0.13 mg) has less riboflavin than equal amount of white enriched bread (0.15 mg). The answer this is that more of the nutrient is added to the wheat flour during enrichment process than was originally present in the whole wheat ain.

oflavin losses during food processing, storage, and cooking

The two factors in the processing, storage, or cooking of a food at may cause a loss of riboflavin are the leaching of the vitamin into e processing or cooking water and the destruction of the vitamin light.

Table 28. Riboflavin Values of Some Typical Foods

Food	mg/100 gm	Portion	mg/serving
ewer's yeast	5.45	1 tbsp.	0.44
ver, beef, cooked	3.96	2 oz	2.25
dney, beef, raw	2.55	3 oz	2.16
eart, beef, raw	0.89	3 oz	0.75
heese, cheddar	0.42	1 oz	0.12
rnip greens, cooked	0.41	⅔ cup	0.39
g, whole	0.29	1 medium	0.14
al cutlet, cooked	0.28	3 oz	0.24
inach, cooked	0.20	⅔ cup	0.24
round beef, cooked	0.19	3 oz	0.16
lmon, canned	0.18	3 oz, ¾ cup	0.16
ilk, whole	0.17	1 cup	0.42
sparagus, cooked	0.17	⅔ cup	0.20
roccoli, cooked	0.15	⅔ cup	0.15
read, white, enriched	0.15	1 slice	0.04
read, whole wheat	0.13	1 slice	0.03
read, white, unenriched	0.08	1 slice	0.02
range juice, fresh	0.03	1 cup	0.06
ugar, white	0.0	1 tsp.	0.0
utter	0.0	1 tbsp.	0.0

From *Composition of Foods—Raw, Processed, Prepared*, U.S. Department of griculture, Agriculture Handbook 8, 1950.

The loss of riboflavin during food preservation and preparation ccurs mostly during the blanching (boiling for a short period prior o preservation by freezing or canning) or cooking process. It has been reported that peas lost 20 per cent of their riboflavin content

while being blanched but relatively no further loss of the vita occurred in the subsequent stages of freezing or canning. Losses the vitamin due to varying amounts of cooking water have b observed. There appears to be about a 20 per cent loss of ribofla from vegetables cooked in a small amount of water (one-half cu and when the water is increased the retention of the vitamin is creased. However, very little riboflavin is destroyed in the ra of temperatures used in common cooking practices because of heat stable nature of the vitamin. Although the solubility of vitamin is not as great as was found either for ascorbic acid or thiamine, the liquid fraction from a processed food should be used order to reclaim that part of the vitamin that has leached out into processing water.

The destruction of riboflavin by light is a serious problem in vi of the fact that one of the important dietary sources of the vitam milk, is often exposed to it. When a bottle of milk is allowed stand on the doorstep on a bright sunny day for a period of 2 hou as much as 85 per cent of its riboflavin value may be destroyed. contrast to this, the exposure of a bottle of milk for 1 hour on rainy, dark day may result in only about 10 per cent of the vitam

Amount of Food (College Men 16–19 years)	Approximate Fraction	Amount of Food (College Women 16–19 years)
1⅛ quarts whole milk		⅞ quart whole milk
1 ounce liver		Less than 1 ounce liver
1¼ cups turnip greens 1⅓ pints ice cream		1 cup turnip greens 1 pint ice cream
2½ eggs 6 ounces ground beef 1 cup spinach		2 eggs 4 ounces ground beef ⅔ cup spinach

Fig. 80. The amount of an individual food needed to provide a certain fracti of the day's Recommended Allowance of riboflavin for college men and wom

:g lost. Most dairies recognize this problem and have made a structive effort to preserve the riboflavin quantity of this food duct. Recently, both paper cartons and amber-colored bottles e been introduced to eliminate light destruction of milk riboflavin. some localities where clear bottles are used, home storage boxes, which the milk is placed upon delivery, have been provided.

guide to the selection of foods to meet the riboflavin need of college n and women

Like ascorbic acid, riboflavin is another of the vitamins that is often y in the food intakes of college men and women. Therefore, vings of commonly used riboflavin-rich foods have been grouped presenting fractions of a college student's need for this nutrient ig. 80). One can readily see that with one quart of milk and a ving of meat, fish, eggs, or cheese, both college men and women ll easily meet their need for this important vitamin factor.

Niacin

The disease, *pellagra*, which is now known to be prevented by an lequate body supply of niacin, has been known for centuries. Although it was once an endemic disease caused by the intake of a diet ferred to as the "Three M's" (meat—salt pork, which was almost all t and no lean—maize, and molasses) and was found to occur in the outhern part of the United States. Pellagra is still prevalent in certain ctions of Italy, Spain, and Rumania where corn products are a staple art of the diet. The characteristic symptoms of pellagra involve the in, the gastrointestinal tract, and the nervous system. Because of s specific lesions, pellagra has often been referred to as the disease the "Three D's" (dermatitis, diarrhea, and dementia). The characteristic dermatitis of pellagra, which is aggravated by sunlight and eat, is bilaterally symmetrical and occurs on the hands, feet, face, orearms, and other parts of the body (Fig. 81). The skin becomes d and the lesions itch and burn. When the mucous membranes of e gastrointestinal tract become affected, the early symptoms include *ossitis*, anorexia, and abdominal pains. As the disorder becomes ore severe, diarrhea occurs. Insomnia, irritability, fear, depression, nd forgetfulness are the first neurological changes observed but as e disorder advances, dementia and paralysis may occur. If pellagra emains untreated, it may prove fatal.

Active work to determine the cause of pellagra began in this country 1914 when the disease was very prevalent in our southern states.



Fig. 81. Advanced pellagra showing (top) dermatitis outlining the exposed ar of the neck as well as the lesions on the back of the hands. (Bottom) Shows t same patient after nicotinamide therapy. (Courtesy Jolliffe and The Upjol Company.)

lthough it had been suggested that pellagra was related to the intake a poor diet, there were many people who believed it was an in- ctious disease. Goldberger and his coworkers, under the auspices the U.S. Public Health Service, were the first to induce and then ire pellagra in healthy men by dietary means. Soon after this assic experiment it was found that brewer's yeast eaten in sufficient mounts would protect a human against developing pellagra. In the eantime, the discovery of a disorder in dogs called *blacktongue*, hich is analogous to human pellagra, was the symptom in the test imal that led to the final identification of this dietary factor. At the niversity of Wisconsin in 1937, Elvehjem and his group isolated a ompound called nicotinamide from a liver concentrate and then emonstrated its effect and that of a related compound, nicotinic id, in curing and preventing blacktongue in dogs. Although the hemical nature of nicotinamide had been known since 1870, its iological value was not recognized until this time. The first suc- essful treatment of human pellagra with either nicotinic acid or icotinamide was reported the same year. In order to avoid con- usion with the name of the tobacco extract, nicotine, the name of he vitamin, nicotinic acid, was changed to niacin soon after its dis- overy. It was Cowgill at Yale who coined the name, niacin, from he letters of the three words—*nic*otinic, *ac*id, and vitam*in*.

roperties of niacin

Niacin occurs in colorless needles (Fig. 82) that have a very bitter aste. Although the vitamin is soluble in water, it is not destroyed y acids, alkalies, light, air, or heat.

unction of niacin

The principal role of niacin, as with thiamine and riboflavin, is as constituent in coenzymes. Niacin is a constituent in coenzyme I nd coenzyme II which are essential for certain oxidation reactions o take place in the body. One of the chief functions of the co- nzymes is the removal of hydrogen (dehydrogenation) from certain ompounds and the transfer of it to others in a series of complex eactions.

The tryptophan-niacin relationship. Recently, it has been demon- trated that one of the essential amino acids, tryptophan, can be con- erted into niacin in the animal body. This relationship between ryptophan and niacin was first reported in 1945 by Krehl and others *13*) at the University of Wisconsin, and since that time reports have hown that humans as well as most animals are able to change the amino cid to the vitamin. Although at present scientists do not know the

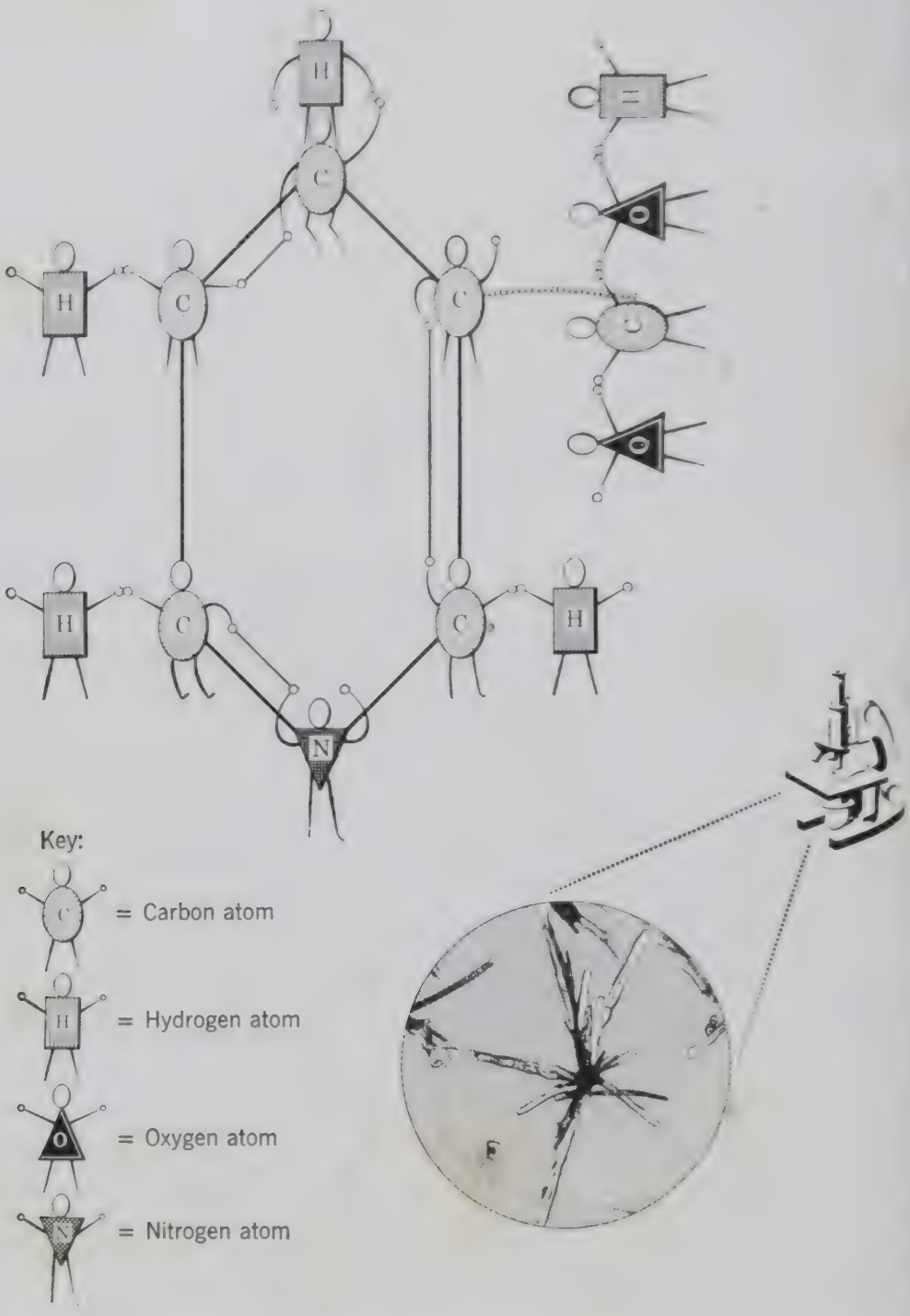


Fig. 82. Crystalline niacin and a diagrammatic representation of its chemic formula. Photomicrograph courtesy Merck and Co., Rahway, N.J.

act mechanism whereby tryptophan can be changed to niacin, it is nown that tryptophan, either as the free amino acid or as a part of e protein molecule, can be used. Because of this biological phe- menon, workers until 1945 had been unable to produce a human acin deficiency by the deprivation of niacin alone in an otherwise lequate diet.

he effects of a niacin deficiency

In animals. Only the dog develops characteristic deficiency symp- oms due to a lack of niacin. Although other animals show symptoms ich as reduced growth, loss of appetite, and weight loss, these condi- ons are only the standard symptoms observed in most vitamin eficiencies. Blacktongue, the term used to describe a niacin defi- iency in a dog, manifests itself in severe lesions of the mouth, a char- cteristic halitosis, diarrhea, emaciation, and a lack of appetite for oth food and water.

In man. The first report of experimentally induced pellagra in nan by dietary means was made by Goldberger and Wheeler in 1915 5). However, after the identification of niacin as the antipellagra actor in 1937, numerous workers tried without success to produce ex- erimental pellagra in man by niacin deprivation. It was not until 952 that Goldsmith and her associates (*6*) at Tulane University were uccessful in inducing human pellagra by the use of corn diets low in iacin and tryptophan. Now it is known that these other workers who had failed to produce a human niacin deficiency had used ex- erimental diets adequate in all known nutrients except niacin, and hat the stumbling block was the presence of adequate tryptophan, which indirectly supplied niacin to the body.

The subjects of Goldsmith's study developed pellagra during the 0 days they were ingesting a corn diet that was low in niacin and ow in tryptophan. At the end of the study they were cured of the isorder with tryptophan which further proved the importance of this mino acid in niacin metabolism. Prior to this work the intake of itamins of the B-complex group other than niacin was recommended o improve the multiple lesions of pellagra. In this study, however, ven though added amounts of these vitamins were present in the iet, the typical lesions of the disorder were produced. This ob- ervation indicates that pellagra is caused by a deficiency of one pecific factor, niacin, and not by a group of factors.

In 1955 the same group of workers (*7*) conducted a similar human xperiment using a wheat diet instead of the typical corn diet that is

associated with pellagra. It was found that the niacin deficiency t
longer to develop and was less severe on the wheat diet than wh
the corn diet was used, even though the diets were comparable
niacin and tryptophan content. The authors point out that the l
tryptophan content of the corn may not be the only explanat
for the pellagragenic effect of this cereal. It may be that the re
tively low digesibility of corn and the low availability of niacin
corn contribute to the earlier development of pellagra on corn diets.

Recommended allowances for niacin

The daily food intake of a college man, 16 to 19 years of a
should provide 25 mg equivalents of niacin; a college man over
years should have 21 mg equivalents. College women, 16 to 19 ye
of age, need about 16 mg equivalents of the vitamin; those over
need about 12 mg equivalents of niacin each day. The National R
search Council suggests that niacin equivalents include dietary sourc
of the preformed vitamin and the precursor, tryptophan: 60 mg try
tophan equals 1 mg niacin.

Niacin allowances for other age and stress groups are given in t
appendix.

Food sources of niacin

Data on the pellagra-preventing potency of foods was reported b
Goldberger and others long before the recognition of niacin as a vit
min. This information was based on studies of humans sufferi
from pellagra and of blacktongue in dogs. Foods were rated
good, *fair*, and *little or none*, depending upon their curative effect
pellagra and blacktongue. Today, with the extensive information
the occurrence of niacin in foods, it has been shown that this earl
rating system corresponds well to the niacin values measured b
present-day procedures.

Although niacin occurs both in plant and animal products, brewer
yeast and peanut butter are the best food sources of the vitam
(Table 29). Glandular meats, muscle meat, poultry, and fish a
rated as excellent niacin foods, whereas eggs are rated as niacin-poo
Milk, although low in actual niacin content, must be classed as a goo
antipellagra food because of its high tryptophan content. Fruits an
vegetables vary in their content of niacin. Whole grain cereals co
tain more of the vitamin than do highly refined cereals even thoug
cereals are low in niacin content. The enrichment of corn and whe
flours in this country has done much to increase the niacin content

Table 29. Niacin Values of Some Typical Foods

Food	mg/100 gm	Portion	mg/serving
ewer's yeast	36.2	1 tbsp.	2.9
anut butter	16.2	1 tbsp.	2.6
ver, beef, cooked	14.8	2 oz	8.4
icken breast, raw	10.5	1 breast (8 oz)	21.1
libut, cooked	10.5	4 oz	13.1
dney, pork, raw	9.8	3 oz	8.4
an flakes, 40 per cent	8.7	1 cup	3.5
eart, beef, raw	7.8	3 oz	6.6
round beef, cooked	4.8	3 oz	4.1
lmonds	4.6	½ cup, shelled	3.3
rnmeal, enriched, cooked	3.5	1 cup	1.1
ead, whole wheat	3.0	1 slice	0.7
read, white, enriched	2.2	1 slice	0.5
rnmeal, unenriched, cooked	1.0	1 cup	0.3
reen peas, canned, drained solids	1.0	⅔ cup	1.1
roccoli, cooked	0.8	⅔ cup	0.8
range juice, fresh	0.2	1 cup	0.6
utter	0.1	1 tbsp.	trace
gg, whole	0.1	1 medium	trace
lilk, whole	0.1	1 cup	0.3
ugar, white	0.0	1 tbsp.	0.0

From *Composition of Foods –Raw, Processed, Prepared*, U.S. Department of Agriculture, Agriculture Handbook 8, 1950.

our diets. A report from the U.S. Department of Agriculture has hown that the national food supply in 1951 contributed 24 per cent nore niacin than it did for the period (1935–1939) prior to the adop- ion of cereal enrichment.

Niacin losses during food processing and preparation

Niacin, which is the most stable vitamin of the B-complex group, s not affected by the common factors encountered in food processing r storage. Because of its water-soluble nature, however, a food may ose some of its niacin during food processing or preparation. The se of a small amount of water in cooking niacin-containing foods will ninimize the loss of the vitamin during the cooking process. The iquid fraction from the processing or preparation of a food should e used in order to reclaim any of the original niacin that was lost rom the food by leaching.

Amount of Food (College Men 16–19 years)	Approximate Fraction	Amount of Food (College Women 16–19 years)
7 ounces chicken breast		5 ounces chicken breast
9 ounces hamburger 3 ounces beef liver		6 ounces hamburger 2 ounces beef liver
2½ tbsp. peanut butter 2 small pork chops		1⅔ tbsp. peanut butter 1 pork chop
6 slices enriched white bread 1 cup green peas 1 cup bran flakes		4 slices enriched white bread ⅔ cup green peas ⅔ cup bran flakes

Fig. 83. The amount of an individual food needed to provide a certain fracti of the day's Recommended Allowance of niacin for college men and women.

A guide to the selection of foods to meet the niacin need of colleg men and women

The fractions of college men's and women's niacin need represente by servings of commonly used foods are listed in Fig. 83. Eve though it is known that the amino acid, tryptophan, in food can b converted to niacin, the portions listed here represent only the actu niacin content. One can readily see that with a well-balanced die it is not difficult for college students between the ages of 16 and 1 years to more than meet their Recommended Allowance for th nutrient.

The enrichment of cereal grains

Nearly 72 per cent of the Calories consumed by the people of th world come from rice, wheat, corn, and other grains. Wheat an rice, however, because of consumer preference and a better keepin quality, are milled to a highly refined form causing a loss of the nutri

ts that are important in regulating the body's use of this food energy. Moreover, diets rich in corn products may be pellagra-producing because of the insufficient amounts of niacin and tryptophan this cereal food. In order to combat the clinical and subclinical deficiency diseases which may result from inadequate amounts of the B-complex vitamins in cereal-rich diets, the enrichment of wheat, corn, and rice products has been adopted.

The Committee on Food and Nutrition of the National Research Council, now known as the Food and Nutrition Board, deserves much credit for the adoption of cereal enrichment in this country. Although the enrichment of white flour and bread began in 1941 under the War Food Order of the Federal Government, South Carolina, in 1942, became the first state to enact legislation which demanded enrichment of all wheat products sold within its boundaries. After the Second World War, when wartime directives ceased to exist, the idea of enrichment was well established as ninteen states had passed legislation requiring it. At the present time, over half the states and several territories have passed enrichment laws, and in the other states approximately 92 per cent of the white bread sold is enriched. In several southern states, where cornmeal is used in large amounts, legislation has been extended to include the enrichment of this product. Just recently South Carolina enacted legislation to include the enrichment of rice.

Thiamine, riboflavin, niacin, and iron are the four nutrients that must be added to white flour or bread under the enrichment law. The addition of vitamin D and calcium are optional but not mandatory. In order for one to see the value of the enrichment of wheat flours, a comparison of the vitamin and iron content of whole wheat, enriched white, and unenriched white flours is presented in Fig. 84. Enriched white flour contains about twice as much riboflavin, but only four-fifths as much thiamine, niacin, and iron as is found in whole-wheat flour. On the other hand, enriched flour contains nine times as much thiamine, six times as much riboflavin, and about four times as much niacin and iron as does unenriched flour. The addition of these nutrients to white flour causes no change in taste, color, or cooking quality.

The value of white flour enrichment to the nutritional well-being of a population has been shown in the famous Newfoundland surveys (*1*, *2*). Prior to the introduction of white enriched flour into Newfoundland in 1944, medical surveys were conducted in two areas of the country. Four years later a resurvey was made in the same areas to determine the benefits derived from such a program. The clinical

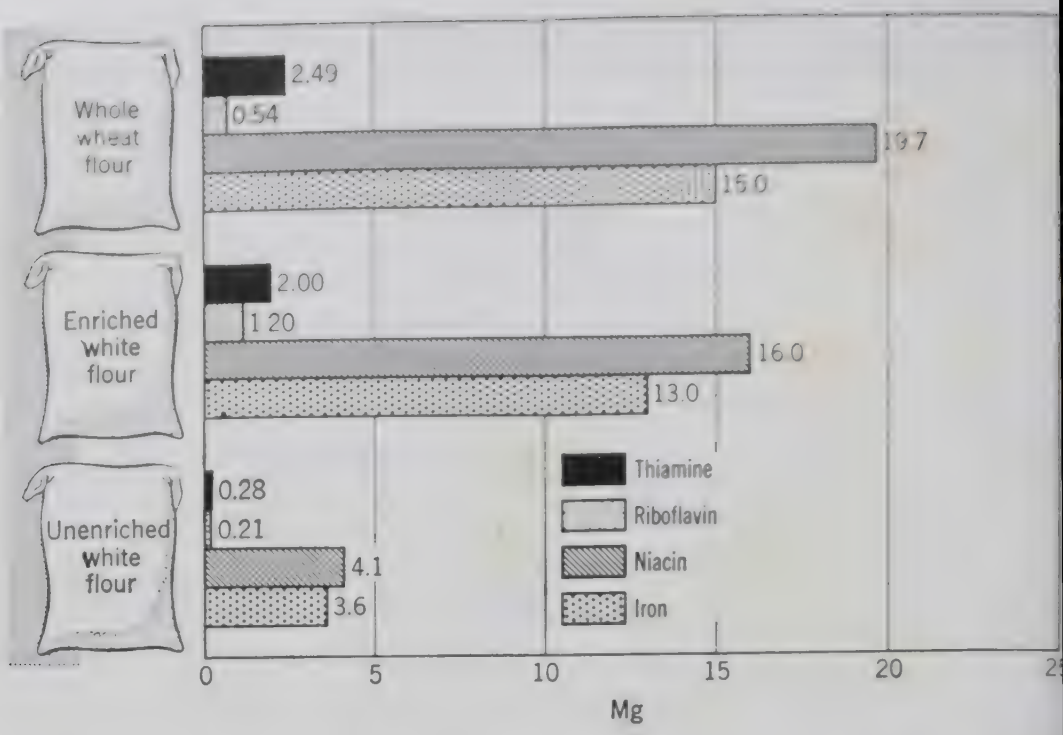


Fig. 84. The vitamin and iron content of one pound of wheat flours. (Adapte from *Composition of Foods,* U.S. Department of Agriculture, Agriculture Hand book 8, 1950.)

signs of malnutrition, following the period of the addition of thiamine riboflavin, and niacin to the diet through the enriched flour, had de creased. By 1948 the general health of the people had improved, bu there was no improvement in the lesions related to ascorbic acid mal nutrition where no dietary supplement of that nutrient had bee provided.

The diets of the people of the United States were improved notably by enrichment of bread and flour. As shown in Table 30 lower in come families benefited relatively more than higher income familie because of a greater consumption of flour and bread.

Rice can be enriched by coating it with a mixture of thiamine niacin, and iron, and this mixture is called *Premix.* When Premix i used in amounts of 1 part to 200 parts of rice, the enriched produc has a nutritive value comparable to brown rice. Riboflavin is no used in rice fortification because it discolors the grains.

The peoples of Asia, who constitute almost one-half of the world' population, eat about 80 to 90 per cent of their Calories in the form o rice. The nutritional shortcomings of rice as a staple food of thei diet are evident in the high incidence of beriberi among the peoples o this continent. The solution for the control of beriberi in the Fa

Table 30. Effect of Flour and Bread Enrichment on the Thiamine, Riboflavin, Niacin, and Iron Content of Urban Diets, Spring 1948

Annual income class (dollars)	Per cent of total nutrient in diet added by enrichment with:			
	Thiamine	Riboflavin	Niacin	Iron
All income classes	16	3	13	12
1000 to 2000	20	5	15	14
5000 to 7500	13	2	9	10

From *Bread*, U.S. Dept. Agr. AIB No. 142, 1955.

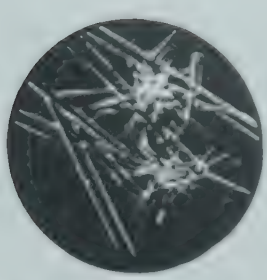
ast appears to be in the enrichment of rice—demonstrated by studies onducted in the Bataan Province of the Philippine Islands (*3*, *4*). ine months after the introduction of enriched rice to the seven exerimental towns it was found that nearly 90 per cent of the people ho had previously shown mild to definite beriberi symptoms were reatly improved. The incidence of death due to beriberi was reuced by 67 per cent during the first year of rice enrichment, and ot one death due to this disease was reported during the latter quarter f the second year. Through the efforts of Dr. R. R. Williams of he Williams-Waterman Fund (*16*) and other scientific and civic eaders, both in the United States and in the Philippines, a plan was dopted in 1955 that brought the entire Philippines under rice enrichent by law late in 1956.

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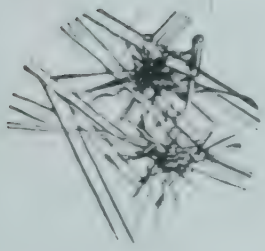
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CHAPTER 16



The B-complex vitamins



I. VITAMIN B_6, PANTOTHENIC ACID, BIOTIN, FOLACIN, VITAMIN B_{12}, CHOLINE, AND INOSITOL

For a substance to be classified as a vitamin, at least two species of animals must need it for the maintenance of normal body function. Although there are other factors of the B-complex family in addition to thiamine, riboflavin, and niacin, that qualify as vitamins according to this definition, not all of them have been shown to be essential for man as yet. It has been more difficult to induce experimental human deficiencies with these factors than it was in the case of the other vitamins that you have already studied. Because of this fact, investigators have used not only deficiency diets in their human studies of these factors, but also in many instances have found it necessary to employ chemical substances called *antagonists*. An antagonist, which may or may not be related chemically to a specific vitamin, will counteract the beneficial effects of the vitamin, and, for this reason, is sometimes called an *antivitamin*. For example, in the induction of experimental pantothenic acid deficiency in man, the subjects were fed omega-methyl pantothenate which is an antagonist of pantothenic acid.

The seven vitamins to be discussed in this chapter are vitamin B_6, pantothenic acid, biotin, folacin, vitamin B_{12}, choline, and inositol. The crystalline structures of four of them are shown in Fig. 85.

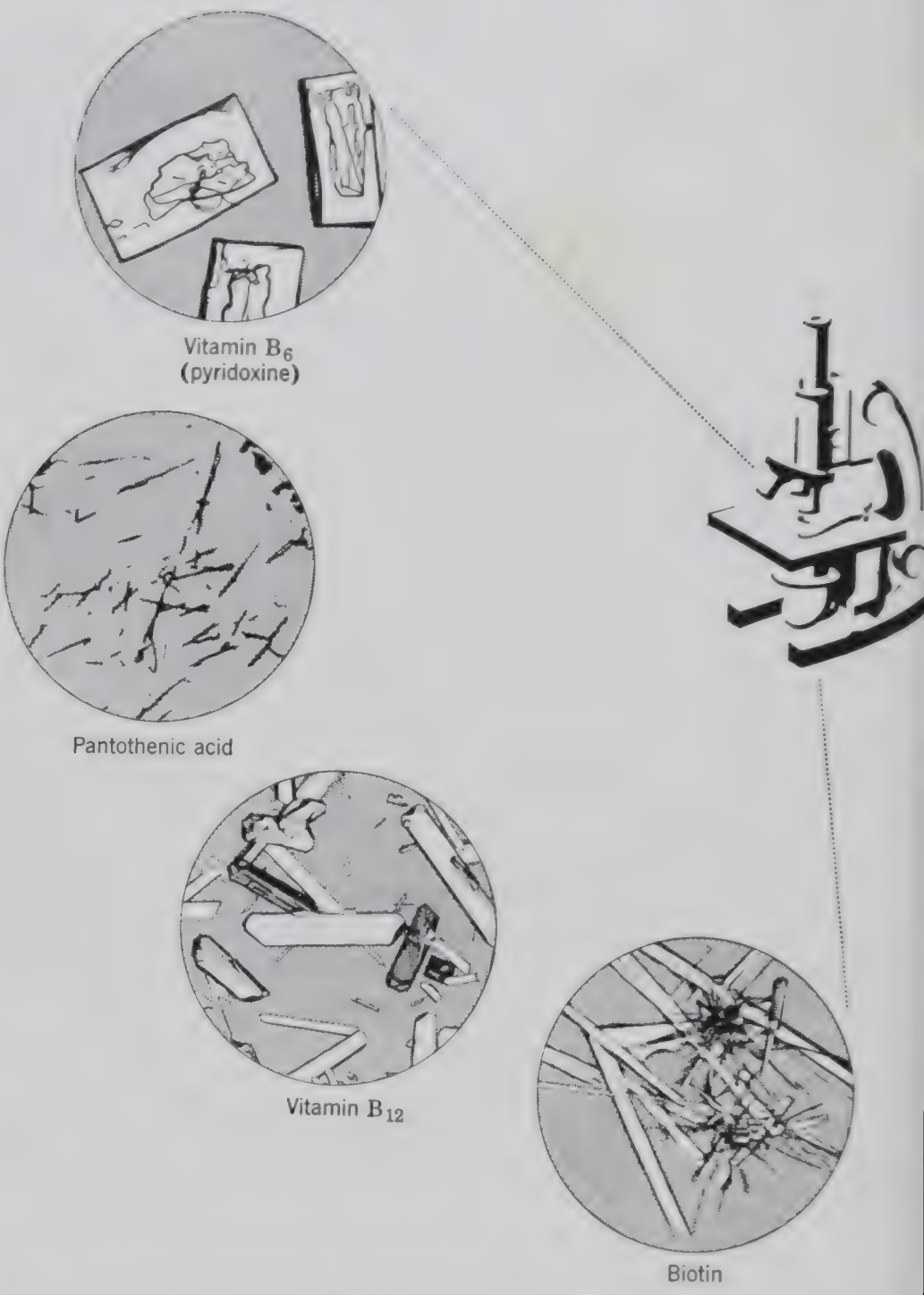


Fig. 85. Crystals of vitamin B_6, pantothenic acid, vitamin B_{12}, and biotin. (Photomicrographs, courtesy Merck and Co., Rahway, N.J.)

asmuch as most of these factors act as coenzymes in the enzyme stems of the body, they may be thought of as quite similar in their nction. Because these vitamins are needed in minute amounts and re found in the commonly-used plants and animal foods of the diet, is not likely that humans will ever experience a deficiency of them. n general, the ordinary practices of food processing and food prep- ration do not significantly affect the content of any of these vitamins n the food intake.

Vitamin B_6

This factor has been called pyridoxine but newer information has hown this designation to be incorrect because vitamin B_6 consists of wo other forms of the vitamin, pyridoxal and pyridoxamine rather han just pyridoxine. Although the vitamin was first identified in 938 as a member of the vitamin B-complex family, only recently nave scientists learned of man's need for it.

Functions of vitamin B_6

Like the other vitamins of the B-complex group that have already been studied, vitamin B_6 plays the role as part of a coenzyme in the body. It is believed that vitamin B_6 is concerned with several enzyme systems that aid in the metabolism of amino acids, fatty acids, and the release of energy. The breakdown of certain amino acids, the formation of new amino acids, and the conversion of the amino acid, tryptophan, to the vitamin, niacin, depend upon the action of this coenzyme.

The effects of a vitamin B_6 deficiency

In animals. All species of animals appear to need vitamin B_6 for normal growth, yet different kinds of symptoms result when different species of animals are deprived of the vitamin. Although the rat loses weight very quickly on a vitamin-B_6-deficient ration, the characteristic lesion in this species is a skin disorder called *acrodynia*, which may develop on the tail, paw, nose, mouth, or ears (Fig. 86). As the deficiency advances, however, the rat may suffer from muscular weakness and convulsions. Vitamin-B_6-deficient dogs, pigs, and monkeys do not show the acrodynia exhibited in rats, but instead develop an anemia in which the red blood cells are small and low in hemoglobin (microcytic hypochromic anemia). Nevertheless, in the later stages of the deficiency, these animals too may suffer from convulsions. Neither the acrodynia nor the anemia are characteristic symptoms of



(*a*)



(*b*)

Fig. 86. The acrodynia-like syndrome of pyridoxine deficiency is characterized by edema and denuding of the ears, paws, and snout (*a*). The same rat is shown again (*b*) completely recovered after three weeks of treatment with pyridoxine hydrochloride. (Courtesy of The Upjohn Company.)

ves deprived of vitamin B_6. These deficient animals show anorexia, lessness, a poor hair coat, and sometimes convulsions.

In man. The human need for vitamin B_6 has been established from privation studies involving both adults and infants. It was necessary to resort to experimentally induced vitamin B_6 deficiency to tablish the need for the vitamin. So widespread is the occurrence vitamin B_6 in foods that a deficiency does not occur naturally. he three symptoms observed in these human experiments of vitamin deficiency were skin lesions, anemia, and convulsive seizures.

To study the effect of vitamin B_6 deprivation in adults (7), eight bjects were fed a low vitamin B_6 diet as well as the antagonist of e vitamin, desoxypyridoxine. After 2 to 3 weeks on this diet, seven the subjects developed a greasy scaliness on the skin about the nose, outh, and eyes (Fig. 87). These lesions remained unchanged when iamine, riboflavin, and niacin were ingested, but disappeared in sev-al days after the administration of vitamin B_6.

The effect of a vitamin B_6 deprivation is more dramatic in the infant an in the adult. The two infants that were studied experimentally y Snyderman and his group (5) stopped gaining weight some weeks



g. 87. Dermatitis in man due to a pyridoxine deficiency induced by the ntivitamin desoxypyridoxine. The skin is red and rough in the nasolabial folds nd on the chin, and the greasy scales are clearly visible. (Courtesy of Vilter, *Lab. Clin. Med.* **42**: 335.)

after being fed a diet deficient in the vitamin. Although one of t infants developed convulsive seizures after 76 days on the diet, t other one showed no convulsive activity pattern but did devel anemia after about 130 days of vitamin deprivation. Both of th conditions, however, were quickly relieved by the administration pyridoxine. Between 1951 and 1953, reports came from various pa of the United States describing symptoms of a nervous irritabili and convulsive seizures in infants less than 6 months old. It w found that all the babies affected had been fed the same commerci canned, liquid-milk formula. A history of the symptoms and trea ment of this disorder in a 2½-month-old infant, who had been fed t liquid milk formula from birth, has been described (*2*). At 4 wee of age the baby appeared to be irritable and showed a stiffening of th body and after 2½ months, it went into convulsive seizures. Thre minutes after the baby had received an intramuscular injection of 1 mg of pyridoxine hydrochloride, the convulsions had stopped and th child's pattern of activity was normal. It is now known that th cause of these convulsive seizures was a lack of vitamin B_6 in th diets of the infants fed that particular preparation because the natur vitamin B_6 of the milk formula had been destroyed by the heat proc essing during its manufacture. The sole use of non-fat milk (skim powder in infant diets might also produce a vitamin B_6 deficiency be cause of the destruction of the vitamin during processing. Althoug vitamin B_6 relieves the convulsive seizures resulting from a deficienc of the nutrient, it has been shown to be of no value in the control o convulsive seizures in the treatment of epilepsy in children (*3*).

Recommended Allowances for vitamin B_6

The human requirement for this vitamin has not been definitely established, but it has been suggested that a daily intake of 1 to 2 mg is needed. Because of the widespread occurrence of this nutrient i both plant and animal foods, this amount will be provided in the average mixed diet.

Food sources of vitamin B_6

Vitamin B_6 is widely distributed among the plant and animal food of one's diet. Although the richest sources of the nutrient have been found in chicken livers and green peppers, brewer's yeast, beef liver fish, lettuce, celery, chicken heart, egg yolk, whole wheat, and lemon are considered to be good vitamin B_6 foods. In view of its daily contribution to the American diets, whole fresh milk which assays about 0.150 mg per pint is a good source of the vitamin.

Pantothenic Acid

About 1940 pantothenic acid received a great deal of publicity be-use of its possible use as a remedy to overcome the graying of hair humans. Based on the observation that the fur of a black-haired t would gray when it was deprived of the vitamin, studies were ndertaken to observe the effects of adequate intakes of pantothenic id on individuals with premature graying of the hair and on elderly ople with gray hair. The findings from these studies indicated, wever, that the vitamin had no consistent effect in relieving the rocess of the graying of hair in man.

unction of pantothenic acid

Pantothenic acid functions in the body as a part of the coenzyme alled *coenzyme A*. Coenzyme A plays an important role in the ody since it is involved in the metabolism of carbohydrates, fats, and roteins (see Chapter 6).

he effects of a pantothenic acid deficiency

In animals and birds. The symptoms of a pantothenic acid defi-iency in birds and animals vary from species to species. The chick hows growth failure and then develops a characteristic type of skin esion which involves the eyelids and the mouth, whereas the fur of a black-haired rat will turn gray when the animal's ration is low or deficient in this nutrient (Fig 88). Other characteristic symptoms hat have been observed when rats are deprived of the vitamin, are the ailure to grow and the degeneration of the cells of the outer layer, he cortex, of the adrenal gland.

In man. The deprivation of pantothenic acid in the diet, alone, as not been effective in producing an experimental deficiency in man. Only recently, when human subjects were fed an antagonist of the vitamin (omega-methyl pantothenate) along with a deficient diet, were symptoms produced (*1*). When pantothenic acid was restored o their diets, however, it alone did not immediately improve all the ymptoms of the deficiency state. Consequently, it is believed that he deficiency effects observed might have been due to the toxicity of the antagonist rather than to a complete lack of pantothenic acid; nly the use of a diet supplemented with all the vitamins brought bout complete recovery in all the subjects. Symptoms developed arly in the experiment with the men showing signs of rapid heart eat on exertion, dizziness, and a lowered blood pressure. Because hey became fatigued easily, the men slept more during the day than



(*a*)



(*b*)

Fig. 88. The general loss of hair color characterizes a pantothenic deficiency in black rats (*a*). A diet adequate in calcium pantothenate restores much of the black pigment within a month (*b*). (Courtesy of The Upjohn Company.)

as normal. During the third week of vitamin deprivation, both anorexia and constipation developed, while in the following week, the men became quarrelsome and discontented. As the deficiency progressed, the subjects complained of numbness and tingling in the hands and feet and showed definite signs of muscular weakness.

Recommended Allowances for pantothenic acid

Although the daily requirement for pantothenic acid is not yet known, it has been suggested to be about 10 mg per day. The average amount in the American diet is about 8.7 mg daily.

Good sources of pantothenic acid

Inasmuch as this vitamin is found in all plant and animal tissues, its name, which was coined from the Greek and means "from everywhere," is appropriately chosen. The richest amounts of the nutrient have been found in liver, kidney, yeast, egg yolk, and fresh vegetables. Milk, meat, grains, fruits, and nuts have been reported to be good sources of the nutrient although egg white, beets, corn, and rice are pantothenic-acid poor.

Biotin

The studies leading to the discovery of biotin began when it was observed that rats fed a ration rich in raw or slightly cooked egg white developed a peculiar skin disorder, showed extreme loss of body hair, and finally died. This condition was referred to as "egg-white injury," and the toxic factor in the egg-white protein which was responsible for the disorder was identified and called *avidin*. Avidin is destroyed when eggs are cooked. Then, a protective factor that counteracted the toxic effect of the avidin was found in such foods as liver and yeast, but it was called by many names such as vitamin H, Factor X, and others before its identification as biotin was established. Now, it is known that the "egg-white injury" occurred when the biotin from a food combined with the avidin of the egg white to form an insoluble substance that could not be absorbed from the intestinal tract.

Function of biotin

To date the exact function of biotin in the animal organism is not known, but it appears that this nutrient is an essential part of certain coenzymes that are involved in the metabolism of carbohydrates, fats, and proteins.



(*a*)



(*b*)



(*c*)

See legend on page 265.

e effects of a biotin deficiency

In animals. The symptoms of a biotin deficiency in animals are ite similar from species to species. In the early stages of a biotin ficiency in a rat, the animal loses hair around the eyes, which pro- ces a characteristic "spectacle eye condition," and as the disorder ogresses, there is a general loss of hair over the entire body (Fig.). Loss of weight, abnormal posture, and a spastic gait are ob- ved in the advanced stages of the deficiency, and death will occur biotin is not restored to the rat's ration.

In man. A biotin deficiency in man has been induced experimen- lly by feeding male subjects a low biotin diet that contained 30 per nt of the total Calories in the form of egg white (*6*). By the end of e first month on the experimental diet, a fine scaliness of the skin as observed in all the subjects. During the ninth and tenth week of e deprivation, the men experienced mild depression, extreme weari- ss, sleepiness, pains in the muscles, and a high degree of sensitiveness the skin. Later, however, they developed anorexia and nausea. ecause the symptoms of the deficiency state disappeared so quickly fter the restoration of biotin to the diets of the subjects, it was con- luded that this vitamin is an essential nutrient for man.

ecommended Allowances for biotin

As yet, a human requirement for biotin has not been established, ut it has been suggested that probably between 0.150 and 0.300 mg f the vitamin is needed daily. Because biotin is widely distributed n foods with the average diet supplying the suggested daily need esides being synthesized in the intestinal tract, it is very unlikely that deficiency of the nutrient occurs in man.

ood sources of biotin

Biotin is found in many foods of both plant and animal origin. he richest food sources of the vitamin are found in kidney and liver, nd good sources of biotin include eggs, milk, most fresh vegetables, nd some fruits. Meat, wheat products, and corn products, how- ver, are considered to be biotin poor.

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g. 89. Egg white injury is a biotin deficiency produced by feeding a rat egg hite, which contains a biotin antagonist, avidin. The resulting dermatitis, which egins around the eyes and produces the characteristic spectacle eye, has pro- ressed in the rat in (*a*) to generalized alopecia. The same rat is shown again (*b*) three weeks after adequate amounts of biotin were added to the diet. Growth has resumed and skin lesions are improved. After three months of reatment, the animal is normal (*c*). (Courtesy of The Upjohn Company.)

Folacin[1]

Long before folacin was either isolated or synthesized, its deficien symptoms had been described in man, animals, and microorganism Inasmuch as many laboratories had studied independently the effe of a folacin deficiency in a variety of species, different names for th nutrient such as vitamin M, vitamin B_c, and *L. casei* factor, had be reported. Now, however, it is known that the biological activity all these factors is identical or related to folacin. Recently a ne factor, called the *citrovorum factor*, has been found which has di ferent physical and chemical properties but has functions similar folacin. Still another substance, with the same biological action the citrovorum factor, has been prepared and given the name *folinic acid*. It is now believed that the citrovorum factor and folin acid are the biological forms of the vitamin and folacin is only th preform or precursor.

Function of folacin

At this time it is known that folacin is necessary for normal bloo formation (*hematopoiesis*) in animals and man, but the exact mecha nism of the vitamin in this process is not yet understood. It has bee suggested that folacin may be involved also in the metabolism of th amino acids, tyrosine and phenylalanine, and the action of folacin t spare but not completely replace the vitamin, choline, in the diets o chicks and birds suggests yet another function for this nutrient (se section on choline).

The effects of a folacin deficiency

In birds and animals. Although all animals have a need for folacin the amount required in the daily ration varies from species to specie because some of them can produce the vitamin by intestinal synthesis The dog, rabbit, and rat meet their need for the vitamin by intestina synthesis, but chicks and monkeys must have folacin in their feed otherwise a deficiency will occur (Fig. 90).

In man. As yet, it is not known if man has a dietary requiremen for folacin but it is known that the vitamin is effective in the relie of certain types of human macrocytic anemias.

For one to understand better the cause and effects of this type o anemia, a brief description of the development and growth of the re

[1] The term adopted in 1949 by the American Institute of Nutrition to replac the name, folic acid.



(*a*)



(*b*)

g. 90. Folic-acid-deficient chick (*a*) is stunted, poorly feathered, and severely nemic. The chick (*b*), taken from the same batch and fed the same ration pplemented with 100 mcg of folic acid per 100 gm ration, shows approx- ately normal growth rate, feathering, and blood values. The chicks are four eeks old. (Courtesy of The Upjohn Company.)

blood cells follows. After the red blood cells are produced in marrow of the bone, they must undergo a process of growth development called *maturation* before the cells are discharged i the blood stream ready to carry on their function in the body. the first stages of their development, the immature red blood c are enlarged, nucleated, and contain little or no hemoglobin. *megaloblast* is an example of this type of immature cell. As matu tion proceeds, the nucleus subsides in size, more and more hemoglo is formed, and the size of the cell is reduced. The mature red blo cell is called an *erythrocyte*. The process of maturation is depend upon the action of certain enzyme systems, and it is believed that is in this role as part of a coenzyme that folacin functions in hema poiesis.

A person suffering from a macrocytic anemia caused by a folac deficiency shows a characteristic blood pattern as well as typi symptoms of the disorder. In the blood stream there are many larg immature megaloblasts and relatively few mature erythrocytes. B cause of this condition, the oxygen-carrying capacity of the cel which have not formed adequate amounts of hemoglobin, is great reduced and results in symptoms of weakness, rapid breathing, a a slowing down of the body processes. The normal growth an development of other blood factors, the white blood cells (*leuc cytes*) and blood platelets (*thrombocytes*) are also altered durin a folacin deficiency. A decrease in the leucocytes, which are th body's chief defense against microorganisms, will result in less resis ance to disease on the part of the anemia patient and his normal proc ess of blood coagulation may be affected by the lowered number o thrombocytes. Besides the effects caused by an alteration of certai blood constituents, the macrocytic anemia patient may show weigh loss, inflammation of the tongue, as well as disturbances of the in testinal tract.

Folacin has been shown to improve hematopoiesis in pernicio anemia, (section on vitamin B_{12}) but it has no effect whatsoever i relieving the neurological disturbances characteristic of this disorde Actually, the vitamin appears to aggravate the neurological lesion which involve the degeneration of the nerve cord. Microcytic-typ anemias (see Chapter 10) do not respond to folacin therapy.

A variety of antagonists of folacin have been identified. Whe these antivitamins, such as aminopterin, are fed to animals, one of th early alterations in the process of hematopoiesis is a reduction in th number of leucocytes or white blood cells produced. As a result o this finding, the administration of folacin antagonists has brough

porary relief, but not a cure, in cases of human leukemia, a disease which there is a marked increase in the production of leucocytes.

ommended Allowance for folacin

Even though the actual human requirement for folacin is not own, the National Research Council has suggested that intakes of than a milligram per day will meet the need for this nutrient.

od sources of folacin

The richest food sources of folacin in the diet are found in chicken ers and vegetables such as asparagus, broccoli, endive, leaf lettuce, d spinach. Liver, legumes, and other leafy green vegetables are od contributors of the vitamin; eggs and milk contain only small ounts of folacin.

Vitamin B_{12}

Ever since 1926 when Minot and Murphy found that pernicious emia (Addison's anemia) could be controlled by the ingestion of hole liver, many laboratories have been searching for the factor re-onsible for this therapeutic action. But it was not until 1948 that ientists isolated a red crystalline material that in very small amounts as beneficial in the relief of this form of anemia. The substance, hich is the most recently discovered vitamin, was named vitamin $_{12}$, and we now know that the two minerals, cobalt and phosphorus, e contained in its chemical structure. Almost 100 years after Addi-n had described the symptoms of pernicious anemia in man, vitamin $_{12}$ was first used by West in the treatment of the disorder. Perni-ous anemia is a chronic disease characterized by a macrocytic emia, glossitis, and neurological disturbances. Stiffness of the mbs, irritability, drowsiness, and depression are some of the typical eurological symptoms experienced by pernicious anemia patients.

nction of vitamin B_{12}

Although vitamin B_{12} is effective in relieving the abnormal blood attern and the neurological symptoms of pernicious anemia, just how e vitamin functions in this process is not yet understood. It is nown that the gastric juice of pernicious anemia patients lacks a bstance present in the gastric secretions of normal persons. It is esignated as *Castle's intrinsic factor*, named for the person who first ecognized the deficiency and who postulated also, an *extrinsic factor*. hat substance is present in foods and is effective in the treatment of ernicious anemia when fed with a source of the intrinsic factor (pre-

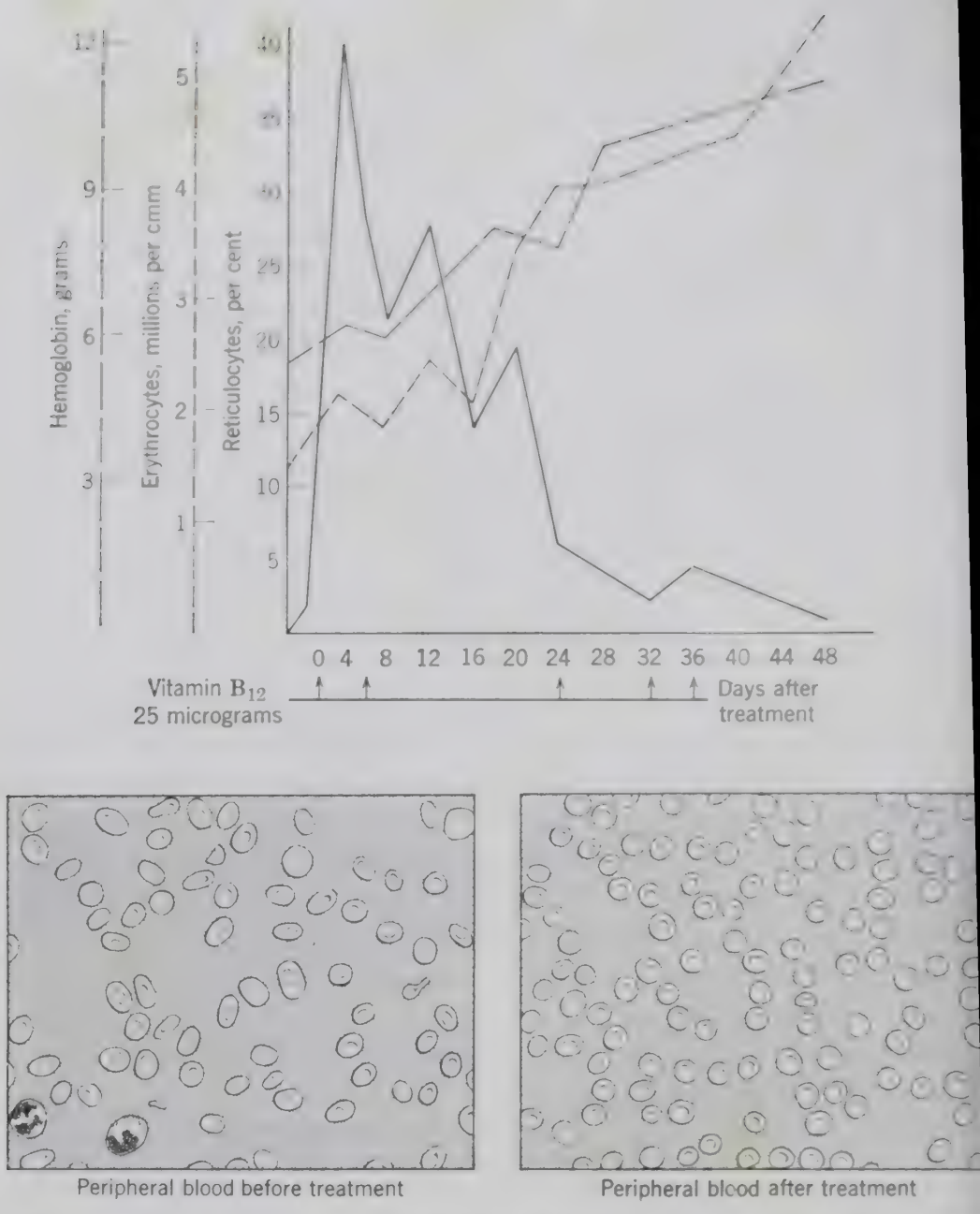


Fig. 91. Patient with pernicious anemia in relapse, typical hematologic respon to treatment with vitamin B_{12}. (Courtesy of Merck, Sharpe and Dohme Researc Laboratories.)

pared from gastric mucosa of hogs and other animals, also availabl from normal gastric juice). Vitamin B_{12} is now recognized as th extrinsic factor. Very minute doses of the vitamin, 10 to 15 mc per day, are effective in relieving the disorder and larger amounts, 2 to 30 mcg given every 3 or 4 weeks, prevents the recurrence of pern cious anemia in patients (Fig. 91). Although folacin is effective improving the anemic condition in pernicious anemia, the use of fola cin alone in the treatment of this type of anemia is dangerous becaus

has been found to accelerate the degeneration of the nerve cord her than to inhibit it.

It has been suggested that vitamin B_{12} may function to promote owth in animals and man. Before the vitamin was discovered, it s shown that an unknown factor found in animal foods was neces- y to stimulate growth in animals and this factor was called the nimal protein factor" (APF). After vitamin B_{12} became available, wever, it was observed that the vitamin had growth-promoting operties similar to APF. Since antibiotics, such as aureomycin, ve been observed to stimulate growth in animals, we now believe at factors other than vitamin B_{12} may be involved. Although a w isolated studies have been reported on the growth-promoting fect of vitamin B_{12} in small numbers of underweight children, fur- er work is necessary before the role of the vitamin as a growth stim- ant for man can be proved.

tamin B_{12} deficiency in man

The first documented case of pernicious anemia in man caused by actual lack of dietary vitamin B_{12} was reported in 1956 (*4*). The haracteristic blood pattern was found in this patient who had ex- ted on an animal-food-free diet for about eight years. The admin- tration of vitamin B_{12}, however, brought about complete relief from he anemia.

ecommended Allowances for vitamin B_{12}

The human requirement for vitamin B_{12}, under normal conditions f health, is unknown. Yet, if your diet contains an adequate amount f milk, eggs, and meat, it is believed that more than a sufficient mount of the nutrient will be available to meet your needs for vita- in B_{12}.

ood sources of vitamin B_{12}

Animal proteins are the chief sources of vitamin B_{12} in the food ntake. A summary of many assay reports of the vitamin B_{12} value f foods shows liver, kidney, oysters, and clams to be excellent ources of the nutrient. Lean beef, milk, veal, lamb, poultry meat, nd salt water fish are considered good vitamin B_{12} foods, whereas ereal grains, vegetables, and legumes are poor carriers of the vitamin.

Choline

There is some doubt as to whether choline should be included in he list of the vitamins because it occurs in the body in very large

amounts and has never been related to a deficiency in man. Be
these two reasons, it is known that choline may be synthesized in
body when sufficient amounts of the amino acid, methionine,
available. Nevertheless, choline has tentatively been included w
the vitamins of the B-complex family because it does occur w
them in foods.

Function of choline

There are three ways in which choline may function in the anim
organism. In the metabolism of proteins, choline aids in the synth
sis of amino acids. The factor plays a role in fat metabolism b
aiding in the transportation and metabolism of fatty acids. Choli
apparently functions in another way by serving as the precursor of
related compound (acetylcholine) which is necessary for the tran
mission of nerve impulses in the nervous system.

The effects of a choline deficiency

In animals and birds. Not all species of animals and birds nee
dietary choline but it has been shown to be an essential factor in th
ration of the rat, chick, and dog. A lack of choline in the diet of th
rat results in a marked accumulation of fat in the liver and an enlarg
ment and hemorrhage of the kidney. The fatty infiltration of th
liver tissue and the kidney damage can be reversed with the admini
tration of either choline or methionine to the animal. Vitamin B_{1}
however, has also been shown to be effective in relieving the symp
toms of this deficiency. Although the characteristic effect of
choline deficiency in chicks is perosis or "slipped tendon disease,"
is believed that both choline and manganese are necessary for the pre
vention of this crippling effect in the chicken (see Fig. 48).

Recommended Allowances and food sources of choline

Since the effects of a choline deficiency have not as yet been ob
served in man, no human requirement for the factor has been sug
gested.

The richest animal sources of this factor are found in egg yolk
glandular meats, and brain; wheat germ and the legumes are th
richest plant sources of choline.

Inositol

Like choline, there has been some question as to whether inosito
should be considered a member of the B-complex family of vitamins

ppears that inositol may be a component of the body tissue rather n a specific nutrient because it is found in foodstuffs and required animals and microorganisms in far greater amounts than are any the other members of the vitamin group. For the time being, vever, inositol is included here because it does occur with the B-nplex group in foods.

e effects of an inositol deficiency

n animals and birds. Although the function of inositol in the mal organism is not known, it has been observed that there is a ardation of growth when the factor is missing in the ration of the use, rat, guinea pig, and chick. Rats also show a loss of hair that haracterized by a "spectacle eye condition" suggestive of the lesion served in a biotin deficiency of this species.

commended Allowances and food sources of inositol

Inasmuch as there is no evidence of the effects of inositol depriva-n in man, the amount of this factor that you might need each day not known.

Heart, liver, wheat germ, yeast, and whole grain cereals have been und to be good food sources of inositol.

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CHAPTER 17

Antibiotics as nutritional factors

Antibiotics are familiar to the student of human nutrition as the peutic agents for use in the treatment of certain illnesses. L familiar perhaps is the function that they serve in animal feedi Whether they have any useful purpose as a dietary factor for t human has not been established. It should be noted that the amou of the antibiotic needed to function effectively as a dietary co ponent is extremely small, only 5 to 20 ppm, whereas the dosages a curative drug are massive, amounting to at least 10 times the le of intake as a dietary substance.

The term *antibiotic* comes from the Greek, meaning "against lif a plausible term for compounds that function to destroy bacter That, of course, is the crux of the value of antibiotics as therapeut agents. The mode of their action as dietary substances is as yet i completely elucidated. There are theories, which will be discuss later in the chapter, following a consideration of their usefulness animal feeding.

Antibiotics improve growth of the young and promote efficiency the utilization of dietary nutrients under certain conditions and certain species. Since the recognition of antibiotics as nutrition factors, the study of their value, particularly for domestic animals, h progressed at a rapid pace, with the advisability of their routine u being critically evaluated (*2*). Only a few of the many pertine studies have been included in this short review of the role of an biotics in animal nutrition.

t on growth and food utilization

he first report of the favorable effect of antibiotics on growth e from a study of chicks at the University of Wisconsin in 1944 Since that time, the many investigations testing various anti-cs with different animals including poultry (chicks and turkey ts), swine, and young calves have demonstrated that the growth ct is in general a common response. Antibiotics are primarily ef-ive in stimulating growth when fed as a supplement to an inade-e diet. The response seems to be nonspecific, however, for ther the diets are inadequate in certain of the vitamins or in pro-, improved growth occurs with antibiotic supplementation.

ct on need for other nutrients

he B vitamins. Antibiotics such as terramycin, aureomycin, and icillin are found to stimulate growth when added to diets contain-suboptimal amounts of certain of the B vitamins (thiamine, ribo-in, pyridoxine, and pantothenic acid). When the diet is adequate growth effect of the added antibiotics is slight (*3*).

rotein. The kind of protein in the diet influences the effective-s of antibiotics in stimulating growth. In the initial studies with cks, antibiotics were found to promote growth when added to a t of plant proteins, but were without effect when fed with proteins animal origin. A further example of the effectiveness of antibiotics supplements to diets containing incomplete proteins is the improve-nt in the growth of rats maintained on a diet that was 90 per cent weight) rice with additions of penicillin, aureomycin, strepto-cin, terramycin, and bacitracin (*8*). When the rice diet was sup-mented with lysine and threonine, the effectiveness of the anti-tics was practically eliminated.

portance in livestock industry

The more efficient utilization of food and more rapid gain in weight poultry and other market animals when fed supplements of anti-tics, has resulted in their extensive use in commercial feed mixtures. ultry showed the most spectacular stimulus to growth. As a result, ctically 80 per cent of the feed used in the poultry industry is cur-tly fortified with one or more antibiotics. It should be noted that dramatic effect originally observed six or seven years ago occurs s frequently with the continued use of antibiotics over the years. metimes introducing a new antibiotic will result in a greater growth mulus.

Mode of action of antibiotics

Precisely how antibiotics function to stimulate growth, prom more efficient utilization of food, and spare certain dietary nutri remains in great part to be explained. The mode of action appea involve the incidence of harmful bacteria in the environment, and be related to the disease level of the animals. In support of this are the numerous studies with chicks that show a difference in sponse if housed in old quarters as contrasted to new. Chicks in quarters benefit from the antibiotic; those in new do not (*4, 6*). same is not always true of swine and cattle.

A change in the bacterial flora of the gastrointestinal tract may plain in part the response of animals to antibiotic feeding (*5*). So evidence comes from the "germ-free" chick studies done at the U versity of Notre Dame. Chicks raised under special germ-free c ditions showed no growth benefits by the additions of certain diet antibiotics, whereas others promoted growth.

Further suggested evidence that antibiotics may exert their act through the bacteria of the intestinal tract is the lack of effectiven on repeated use of antibiotics with poultry. Changing to a n antibiotic resulting in renewed stimulus to growth would seem to dicate that the bacteria may become "resistant" to antibiotics w their use.

The appearance in the gastrointestinal tract, when antibiotics fed, of microorganisms that synthesize the deficient vitamins may the explanation for the effectiveness of these substances in deficienc of the B vitamins. The mechanism of action of the antibiotic w protein remains somewhat of a riddle. Long time feeding expe ments with rats indicate that antibiotics may not favor the storage protein, but increase the storage of energy as fat.

It may be that antibiotics as nutritional factors are effective throu their influence on the bacteria of the gastrointestinal tract in mo than one way. They may act to (*a*) reduce the level of harmf bacteria in the intestinal tract; (*b*) increase the level of organis that synthesize the nutrients needed by the animal—these nutrien may be those which we already recognize as essential or those whi are still unidentified; and (*c*) decrease the level of those bacteria th compete with the animal for essential nutrients (*7*).

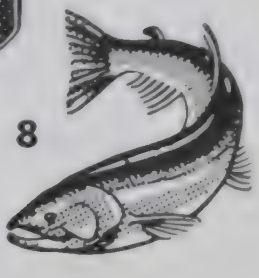
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CHAPTER 18







Selection of an adequate diet



An adequate diet is one that provides all the known essential nut ents in sufficient quantities to meet the needs of the body. Thus f we have discussed in some detail the energy and nutrient needs inclu ing protein, the minerals, vitamins, and water. We now bring gether the information concerning each of the nutrients in terms food for the day. Easy rule of thumb methods for knowing whi foods and how much of each are needed to provide an adequate d have been developed on the basis of *food groups;* for this purpo foods that are similar in nutritive value are considered together as group. The pattern for the adequate diet is developed by reco mending sufficient servings of foods from the various groups to pr vide the needed nutrients.

Guides for Planning an Adequate Diet

Two of the plans for selecting an adequate diet will be discusse one is developed around 7 *food groups*, the other around 4 *fo*

ups. There are still other plans, developed on the same principle he 7-group and 4-group plans, differing only in number of groups. of the plans are developed in accordance with food habits of the ple of the United States and the foods available to them. In other ntries where the habits of eating and the food supply are different, food patterns are of necessity different also.

Both the 7- and the 4-group plans are flexible, allowing for a wide ice of foods within most of the groups. Meals planned in one ne are likely to differ from those in another, even though the meals each home follow the same food pattern. Foods selected by per- s eating out may vary widely, and still at the same time each is in mplete accordance with the recommendations of the same food tern. The choice of foods within the groups allows for a wide iety of food combinations that satisfy the plans for an adequate t.

e 7-food group plan

A pattern developed with 7 food groups and designated as "The sic 7" came into being during wartime (1943), and has been widely ed ever since. The 7 groups are given in Fig. 92 together with the mber of servings from each group recommended for an adequate ily diet, and the main nutritive contribution of each group. If fficient Calories are not provided by the above servings, additional ods from any of the groups may be selected, or other foods not ted, such as desserts, may be included.

e 4-food group plan

The 4-group plan, developed more recently (1956), combines some the groups in the 7-group plan, reducing the number to 4. The oups are given in Fig. 93, with the quantities of each group recom- ended daily to provide the foundation of an adequate diet, and the ain nutritive contribution of each group. Calories are the least well pplied by the pattern. However, as a usual practice, fats and gars, which are not listed, are eaten as such or combined in baked ods and desserts, with a result that the energy intake is increased so in order to satisfy the appetite, additional servings from the food oups may be expected which will contribute both to the energy and trient intake.

The percentages of the daily Recommended Allowances provided the foundation pattern will vary with individual needs. The per- n with a greater requirement will have those needs less well satisfied,

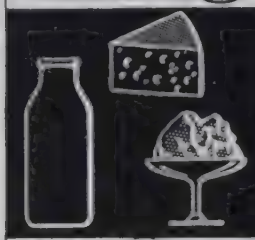
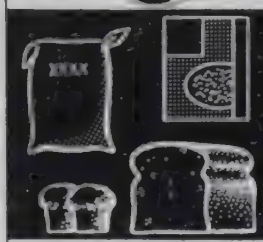
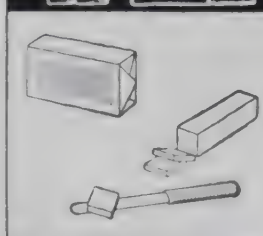
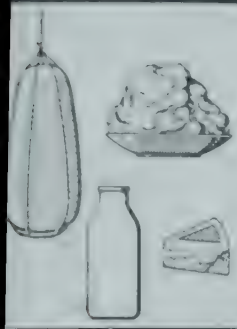
The 7 food groups	Daily amounts	Main nutritive contributions
 Green and yellow vegetables	1 or more servings	Vitamin A value Ascorbic acid Iron
 Oranges, grapefruit, tomatoes... or raw cabbage or salad greens	1 serving	Ascorbic acid
 Potatoes, other vegetables and fruits	2 or more servings	Vitamins and minerals in general Cellulose
 Milk and milk products	Children ¾ to 1 quart Adults 1 pint	Calcium Riboflavin Protein Phosphorus
 Meat, poultry, fish and eggs	1 serving meat, fish or poultry 1 egg (at least 4 a week)	Protein Phosphorus Iron B-vitamins
 Bread, flour and cereal (whole grain enriched or restored)	3 or more servings	Thiamine Niacin Riboflavin Iron Carbohydrate Cellulose
 Butter or fortified margarine	2–3 tbsp.	Vitamin A Fat

Fig. 92. The basic 7 food groups. (From *Natl. Wartime Nutrition Guide*, U.S. Department of Agriculture.)

The 4 food groups	Daily amounts	Main nutritive contributions
 Milk group: Milk, cheese, ice cream (cheese and ice cream can replace part of the milk)	Children 3–4 cups Teen agers 4 or more cups Adults 2 or more cups Pregnant women 4 or more cups Nursing mothers 6 or more cups	Calcium Riboflavin Protein Phosphorus
 Meat group: Beef, veal, pork, lamb, poultry, fish, eggs	2 or more servings	Protein Phosphorus Iron B-vitamins
 Vegetable–fruit group	4 or more serv., including a dark green or deep yellow vegetable at least every other day. A citrus fruit or other fruit or vegetable rich in ascorbic acid–daily Other fruits and vegetables including potatoes	Vitamins Minerals Cellulose
 Bread–cereals group: (Whole grain, enriched, restored)	4 or more servings	Thiamine Niacin Riboflavin Iron Carbohydrates Cellulose

g. 93. The 4-food group plan. (Adapted from *Essentials of An Adequate iet.* U.S. Department of Agriculture. Agriculture Information Bulletin 160, 956.)

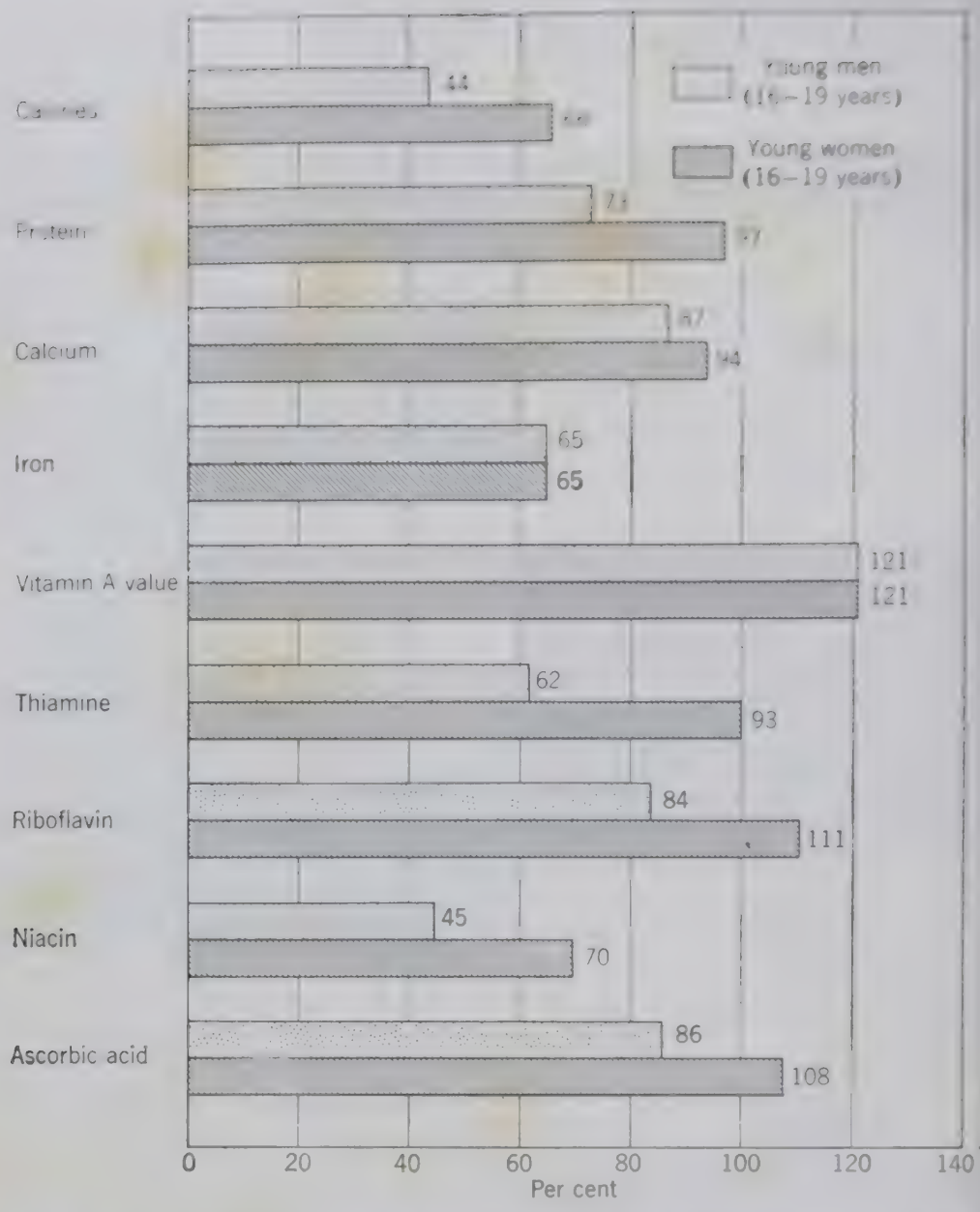


Fig. 94. The contribution of four food groups to the NRC Recommended Dail Allowances. (Adapted for 16 to 19 year old from *Essentials of An Adequat Diet*, U.S. Department of Agriculture, p. 2, 1956.)

of course, than the person with a lesser daily need. For example young men 16 to 19 years of age obtain a lower percentage of thei allowance by the pattern than young women of the same age group simply because the recommendations for the men are higher for some nutrients than for women (Fig. 94). However, the young man, i satisfying his energy need, promoted by a natural urge to eat, select more of all food groups. The result is that in actual practice the

s of young men are, as a rule, more nearly adequate than those of ng women.

oth the 7- and 4-group plans are useful educational tools. The roup method is simplified by placing the fruits and vegetables in grouping, and omitting the butter and fortified margarine group rely.

The Nutritive Value of Food Commodities

ach food group, and each food within the group, makes a particu- contribution to the nutrient content of the diet. Some foods sup- many more of the nutrients and in much greater concentration n do others. The nutritional contribution of the major food mmodities, milk and milk products; meat, fish, and poultry; getables and fruits; and cereal and cereal products, will be discussed the following paragraphs.

lk and milk products

Milk is described as nature's "most nearly perfect food." Some of of the known essential nutrients are found in milk; it is a much tter source of some than others. Milk and milk products are excel- nt sources of calcium, protein, and riboflavin. Vitamin A, phos- orus, and thiamine are also supplied in good amounts. Milk and ilk products are poor sources of iron and of ascorbic acid (Table).

The importance of including milk or milk products in the diet in der to obtain sufficient calcium was discussed in Chapter 9. For udents, or anyone for that matter, drinking milk is one of the best ays of assuring an adequate calcium intake. Each gram of milk ntains about 1 mg of calcium, with a glass of milk supplying about e-fourth of the recommended calcium intake for the college udent.

Milk contains protein of high biological value; it is an efficient sup- ement to the incomplete proteins of cereal products, fruits, and getables. As milk can very well be served as a beverage at each eal of the day, a source of complete protein is thus assured. An sy way to remember the protein value of milk is that each ounce ntains about 1 gm of protein. With a quart of milk costing about cents (a variable factor, of course) and supplying 32 gm of pro- n, a gram of milk protein costs less than one cent.

Evaporated milk contains the same nutrients as whole milk. The ocess of evaporation, and pasteurization also, reduces by about

Table 31. Nutritive Value of Milk and Some Milk Products

Milk and Milk Products	Calories	Protein, gm	Calcium, mg	Iron, mg	Vitamin A, I.U.	Thiamine, mg	Riboflavin, mg	A... Ac... m...
Milk, whole, 1 c.	166	8.5	288	0.2	390	0.09	0.42	
Buttermilk, 1 c. (cultured, skim)	86	8.5	288	0.2	10	0.09	0.43	
Evaporated, 1 c. (water added)	173	8.8	306	0.2	505	0.06	0.46	
Dried skim milk, 1 c. (reconstituted)*	84	8.1	294	0.2	trace	0.09	0.45	
Cheese, cheddar, 1 oz	113	7.1	206	0.3	400	0.01	0.12	
Cheese, cottage, ½ c. (skim milk)	108	21.9	108	0.3	25	0.02	0.35	
Ice cream, ⅐ qt	167	3.2	100	0.1	420	0.03	0.15	

From *Composition of Foods—Raw, Processed, Prepared.* U.S. Department of Agriculture, Agriculture Handbook 8, 1950.

* Computed.

one-fifth to one-fourth the thiamine and ascorbic acid conte... Evaporated milk is convenient to use and economical to purchase.

The fortification of milk with vitamin D is a good public hea... measure. By adding vitamin D to milk the essential nutrients f... bone formation, calcium, phosphorus, protein, and vitamin D, a... brought together in one food.

The popularity of nonfat milk solids is increasing with the Ame... can homemaker. She seems to appreciate the lower cost, ease ... storage, and lower energy value. With the removal of cream fro... the milk, which is done prior to drying, the caloric value is reduced b... about one-half. In addition, vitamin A and the other fat-soluble vit... mins are removed. Because we depend on milk to provide some ... the vitamin A need, if nonfat milk solids is used to replace the who... milk, care must be taken to provide for additional vitamin A valu... from other sources such as green and yellow vegetables and liver.

An ounce of cheddar-type cheese provides about the same nutritiv... value as a glass of milk. In the manufacture of cheese some of th... whey is removed, taking with it some of the water-soluble nutrien... including lactose, the water-soluble vitamins (B-group), and mineral... Cottage cheese made with rennet has a higher calcium content tha... that made entirely by souring of the milk (acid coagulation). ... calcium is soluble in an acid medium, it is carried into the whey whe... the cheese is made by the souring process.

eat, fish, poultry, and eggs

Meat, fish, and poultry are somewhat similar in nutritive value. heir outstanding nutrient contributions are protein and iron, with me phosphorus, thiamine, riboflavin, and niacin.

The protein in this group of foods, as in milk, is of high biological lue. A 3-oz serving of meat supplies approximately 20 gm of pro- n, which is about one-fifth the Recommended Allowance for ung men 16 to 19 years of age, one-fourth the Recommended Al- wance for young women of that age.

Iron is present in relatively high concentration in the organ meats, pecially liver and kidney, and in somewhat lesser amounts in muscle ssues. Meat is a poor source of calcium. Some fish products, iefly shell fish and canned salmon, in which a portion of the bone edible, are somewhat better than meat as a source of calcium.

Pork muscle is high in thiamine content, whereas other muscle eats contain only moderate amounts. The glandular organs, liver, idney, heart, and tongue are higher than muscle meats in riboflavin ontent. Liver, the storage place for vitamin A, is the only edible nimal tissue containing any appreciable amount of this vitamin.

Eggs are important for their protein, iron, phosphorus, vitamin A, nd riboflavin contributions to the diet. Protein in the egg, which is ocated both in the yolk and the white, is of good biological value. One egg contains about 6 gm of protein, approximately two-thirds he amount in one glass of milk. Phosphorus is distributed in both he white and the yolk. Iron and vitamin A are contained only in he yolk. Table 32 gives the nutritive value of some kinds of meat, ish, poultry, and eggs.

Table 32. Nutritive Value of Some Meat, Fish, Poultry, and Egg

Food	Calories	Protein, gm	Calcium, mg	Iron, mg	Thiamine, mg	Riboflavin, mg	Vitamin A, I.U.
Beef, round (3 oz)	197	23.0	9	2.9	0.06	0.19	...
Beef liver (3 oz)	177	20.1	8	6.6	0.22	3.38	45,495
Pork, loin (3 oz)	284	20.0	9	2.6	0.71	0.20	...
Chicken (3 oz)	169	25.3	12	1.5	0.03	0.14	...
Salmon (3 oz)	173	16.8	1	0.8	0.02	0.12	200
Egg (1 each)	77	6.1	26	1.3	0.05	0.14	550

From *Composition of Foods—Raw, Processed, Prepared.* U.S. Department of Agriculture, Agriculture Handbook 8, 1950; and Bowes and Church, *Food Values of Portions commonly used*, 8th ed. 1956 Philadelphia 6.

Vegetables and fruits

As a group, vegetables and fruits contribute minerals, vitamins, a cellulose to the diet. Not to be disregarded is the interest they a because of their variety in color, flavor, and texture. The gr number of fruits and vegetables available for use differ markedly nutrient content. For the sake of clarity they are grouped accordi to their contribution of nutrients to the diet.

In general the green and yellow vegetables and fruits are outstan ing in their vitamin A values. One serving of sweet potatoes, carro kale, or cantaloupe furnishes the Recommended Allowance of vitam A for anyone in the family. In addition, leafy green vegetables a higher in calcium, iron, ascorbic acid, and the B-vitamins than oth vegetables. Some of the green vegetables, spinach, chard, sorrel, an beet greens contain oxalic acid, which combines with calcium durin digestion forming an insoluble salt that cannot be absorbed, an makes the calcium in those vegetables of no use to the body. How ever, these green vegetables, even though not supplying calcium, ar invaluable in the diet for the generous amounts of iron, ascorbic aci and vitamin A value they provide. The ascorbic acid content o broccoli, Brussels sprouts, kale, and similar vegetables is particularl high.

Head lettuce, celery, cabbage, and other light green vegetables ar important for their cellulose content. Raw cabbage is a good sourc of ascorbic acid. The light green vegetables are low in vitamin A value; we call attention to this because of the association of the gree color with vitamin A value.

Citrus fruits and tomatoes are dependable sources of ascorbic acid Tomato juice contains about one-third as much as the citrus fruits. Because they are available in some form the year round and are wel liked, it is customary to include citrus fruits in most dietary plans. Other foods such as strawberries, cantaloupes, kale, and green pep- pers are about as rich in ascorbic acid as citrus fruits, but because of cost, unavailability, or lack of acceptance, do not fit into the diet as a routine item as well as citrus fruits. Ascorbic acid is easily destroyed during storage, freezing, and cooking. Citrus fruits retain their as- corbic acid content better than other foods due to the preserving action of the acids they contain.

Vegetables of the seed, root, and tuber classes, like Lima beans, green peas, sweet potatoes, and white potatoes are higher in carbohy- drate content than other varieties. Starch is stored in these areas of the plant's structure.

Vegetables and fruits are low in protein, fat, and total Calories. ible 33 shows the contribution of some fruits and vegetables to the t.

Table 33. Nutritive Value of Some Fruits and Vegetables

Food	Calories	Protein, gm	Calcium, mg	Iron, mg	Vitamin A, I.U.	Thiamine, mg	Riboflavin, mg	Ascorbic Acid, mg
ple (1 med.)	76	0.4	8	0.4	120	0.05	0.04	6
nana (1 med.)	88	1.2	8	0.6	430	0.04	0.05	10
ccoli, ck., (1 c.)	44	5.0	195	2.0	5100	0.10	0.22	111
bbage, ck., (1 c.)	40	2.4	78	0.8	150	0.08	0.08	53
rrots, ck., (1 c.)	44	0.9	38	0.9	18130	0.07	0.07	6
reen beans, ck., (1 c.)	27	1.8	45	0.9	830	0.09	0.12	18
le, ck., (1 c.)	45	4.3	248	2.4	9220	0.08	0.25	56
ttuce (50 gm)	7	0.6	11	0.2	270	0.02	0.04	4
ma beans, cooked, (1 c.)	152	8.0	46	2.7	290	0.22	0.14	24
range juice (fresh, 1 c.)	108	2.0	47	0.5	460	0.19	0.06	122
neapple (fresh, 1 c.)	74	0.6	22	0.4	180	0.12	0.04	33
tato, white, baked (1 med.)	97	2.4	13	0.8	20	0.11	0.05	17
mato juice (1 c.)	50	2.4	17	1.0	2540	0.12	0.07	38

From *Composition of Foods—Raw, Processed, Prepared.* U.S. Department of Agriculture, Agriculture Handbook 8, 1950.

ereals and cereal products

Cereals are seeds of the grass family—wheat, corn, rice, oats, rye, nd barley. From these cereal grains, flours (whole wheat, white, ye, barley, etc.) are manufactured for the preparation of the many arieties of breads, cakes, pastries, breakfast cereals, macaroni products, hominy, corn syrup, corn meal, and other products. Figure 95 nows the parts of a wheat kernel; other cereal grains are similar in ructure. Whole wheat has the following composition in terms of rams of the constituent per 100 gm of whole wheat: 72 carbohyrate, 2 fiber, 12 protein, 2 fat, 2 ash, and 10 moisture.

In many of our neighboring countries cereals are the main food of ne diet, furnishing 50 to 90 per cent of the total Calories; in the Jnited States about one-third of our Calories is from cereal or ereal products. We grow more wheat and corn in this country than ther cereals; most of the wheat is used for human consumption, a rge part of the corn is fed to livestock.

The cereal grains are easy to grow, easy to store, and have good eeping qualities. Whole grain cereals contribute Calories (mainly the form of carbohydrate), thiamine, iron, riboflavin, and partially

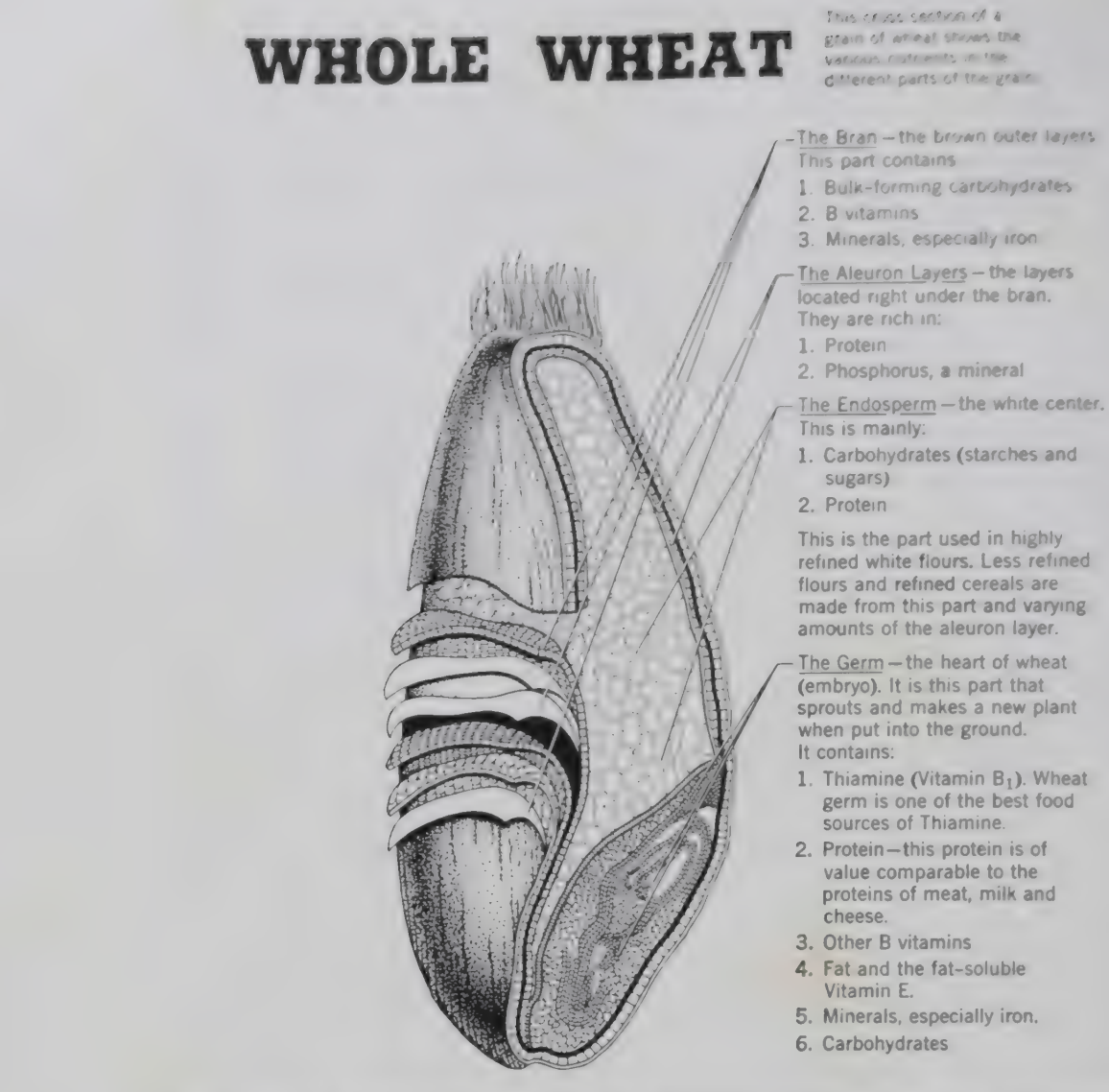


Fig. 95. The whole wheat kernel, its structure, composition, and nutritive value (Courtesy Ralston Purina Company.)

incomplete protein. Cereals are easy to digest, have a bland flavor and supply roughage or cellulose.

In the preparation of cereal products for the market, parts of the cereal grain are removed. In the case of brown rice only the outer husk is removed, whereas in the preparation of white rice all of the outer coats are removed, leaving mainly the endosperm (center) portion. Whole wheat flour is made from the entire grain, with the exception of the husk; white flour is just the endosperm portion. Most of the cellulose, minerals, and B vitamins are in the outer layers or coats of the grain. The endosperm portion contains the carbohydrate and incomplete protein. The germ contains most of the fa

the grain and some of the thiamine. Because the fat tends to be- ne rancid during storage and also seems to hold a great attraction insects, the germ is usually removed in milling. Furthermore, public prefers the refined product for most uses.

The protein in cereal products varies in biological efficiency but a whole is classified as partially incomplete. However, with sup- mentation of protein from milk or meat or eggs to improve the equacy, the cereal proteins make a significant contribution to the t. About 20 per cent of the protein in the average American tary is from cereal sources; on low cost dietaries the percentage is latively higher. Milk and cereal make a good nutritional team. real supplying iron, thiamine, and partially complete protein, and lk providing calcium, vitamin A, and complete protein. The use milk solids (dried milk) in bread improves the nutritive contribu- ons of this product.

The importance of restoring to milled cereals the nutrients lost in e milling process is discussed in Chapter 15. It is important that

Table 34. Nutritive Value of Some Cereals and Cereal Products

Cereal and Cereal Products	Calories	Protein, gm	Calcium, mg	Phosphorus, mg	Iron, mg	Thiamine, mg	Riboflavin, mg	Niacin, mg	Ascorbic Acid, mg
atmeal (1 c.) (cooked)	148	5.4	21	158	1.7	0.22	0.05	0.4	0
ice, white (1 c.) (cooked)	201	4.2	13	76	0.5	0.02	0.01	0.7	0
lacaroni (cooked) (1 c.) (unenriched)	209	7.1	13	91	0.8	0.03	0.02	0.7	0
lacaroni (cooked) (1 c.) (enriched)	209	7.1	13	91	1.5	0.24	0.15	2.0	0
ake, plain (3 × 2 × 1½)	180	3.5	85	75	0.2	0.02	0.05	0.2	0
read, white (1 sl.) (unenriched)	63	2.0	18	21	0.1	0.01	0.02	0.2	0
read, whole wheat (1 slice)	55	2.1	22	60	0.5	0.07	0.03	0.7	0
luffin (1 each) (enriched)	134	3.8	99	92	0.8	0.09	0.10	0.7	0
iscuit (2½" diam.) (enriched)	129	3.1	83	73	0.7	0.09	0.08	0.7	0
oll (pan roll) (16 per pound) (enriched)	86	2.5	15	27	0.5	0.07	0.04	0.6	0

From *Composition of Foods—Raw, Processed, Prepared.* U.S. Department of Agriculture, Agriculture Handbook 8, 1950.

whole grain, restored or enriched cereals, and cereal products selected for the diet in order to benefit from their greater nutritive contributions. Table 34 gives the nutritive contributions of some cereal products to the diet.

Methods of Assessing the Adequacy of Diets

How do we know that a diet which we have planned or one that is consumed is adequate in nutrient content? There are numerous procedures for assessing the nutritive value of the diet. One of the most simple is the use of a "score card." We have already discussed the use of a food pattern as a guide in planning an adequate diet, and score cards have been developed for determining how well the diet meets the suggested pattern. A more precise method of evaluating the nutritive adequacy of diets is computing the nutrient content of each food using a food composition table. The most precise method of all is actual laboratory determination of the energy, protein, mineral, and vitamin content. The choice of the procedure for evaluating the energy and nutrient content of a diet depends on the use to be made of the findings and the accuracy with which the food consumption data were collected.

Use of dietary score cards

Dietary score cards set up for evaluating the diet on the basis of food groups are used chiefly as a basis for nutrition education programs (Table 35). A limitation of the score card is its failure to give the nutritive contribution of each food completely. On the other hand, it is a commendable educational tool in that it encourages the use of a varied diet, and provides a good "rule of thumb" for the selection of an adequate diet.

Use of food composition tables

By far the most common method of determining the nutrient content of the diet is the use of food composition tables (*1*). From the earliest chapters in the text you have used information from food tables in the study of the energy value and content of the different nutrients of various foods. The values for the nutrients were originally obtained by laboratory analysis with each representing many determinations; the energy values are computed from the carbohydrate, fat, and protein content.

There is found to exist a wide variation in the composition of the same food, particularly fruits and vegetables. Growing conditions

Table 35. A Dietary Score Card

Foods	Each Day You Need	Score for One Day	Your Score
en and yellow vegetables (raw or ooked in small amount of water)	1 serving	10	
nges, grapefruit, tomatoes, or other itamin-C-rich food	1 serving	10	
atoes and other vegetables and fruits	3 servings	5	
lk and milk products	Children, 3–4 cups Adolescents, 3–4 cups Adults, 2 cups	20	
eat, poultry, or fish	1 serving	15	
eat, poultry, fish, or meat alternates (dried beans, peas, peanut butter)	1 serving	10	
gs	1 daily (at least 4 a week)	5	
ereal, whole grain or enriched or 2 slices bread	1 serving	5	
ead, whole grain or enriched	1 or 2 slices at every meal	5	
tter or other fats	2 to 3 level tbsp. butter or enriched margarine	5	
good breakfast, including some form of protein, as milk or egg		10	
	Total	100	

riety, fertilizer treatment, care in handling, all make a difference. reparation of the food for the table, preservation, and storage also ve an influence on the composition of most foods. Those who ve compiled food tables have had to decide on the values that they nsidered most representative for inclusion in the table. The neces- y of exercising judgment in preparing a food table accounts for

some of the differences that exist among the compilations of fo composition values. As a rule, the most recent food table inclu new data that add to the accuracy.

Short methods using a food composition table

Short methods for dietary calculation have been developed which foods similar in composition are grouped together, a repr sentative value for each of the nutrients is calculated, and the valu assembled in a table. Totalling the amount of foods of like co position in a diet and computing the nutritive contribution of t group is shorter, of course, than computing each food separately (s Table A-4 in Appendix). That is the manner in which the sho methods save time in calculation.

The short methods are found to agree with the long or usu method if applied to a varied diet, and if the food habits do not diff widely from the usual pattern of the dietary habits of the people this country as a whole. In regions where there is a relatively high intake of certain foods, such as corn meal in the Southern region, revision in the cereal and bread portion of the table becomes necessar to obtain an accuracy approaching that of calculating each food in dividually. For survey studies the shorter method of dietary ca culation has been found satisfactory. Time required for computatio can be reduced without great sacrifice to accuracy.

Chemical analysis

In research studies designed to determine quantitatively the nutrien intake as part of a metabolic balance study, the composition of a foo is determined by laboratory analysis rather than by use of a foo composition table. Laboratory analysis is the most accurate of any procedure for determining the nutritive value of food, since th nutrient content of some foods varies widely. To illustrate, th ascorbic acid content of 13 different varieties of potatoes ranged from 8.2 to 17.4 mg per 100 gm fresh weight, and for 35 varieties of cabbag from 32.4 to 100.7 mg per 100 gm of fresh weight (*4*, *5*). It should be recognized, however, that the ascorbic acid content of foods varie more than for most nutrients, and that fruits and vegetables vary more in composition than most other foods.

The differences between computed and analyzed values for given diets have been studied. It is generally concluded that agreemen is sufficiently close to warrant the use of food tables in dietary surveys reserving laboratory analyses for controlled studies.

Planning a Family Food Budget

Ultimately a market list and a plan for purchasing food must be de by families who maintain households, and by agencies who ke allowances for families in need of assistance. The Institute of me Economics of the U.S. Department of Agriculture prepares terials that are of genuine assistance as guides in planning food dgets. The quantities and kinds of foods needed to adequately urish different individuals are estimated at low-cost, moderate-cost, d a more expensive diet. The Institute has prepared plans for 20 e-sex groups and for 11 food commodity groups, including milk d milk products; meat, poultry, fish; eggs; dry beans, peas, and nuts; ain products; potatoes; citrus fruits, tomatoes; dark green and dark llow vegetables; other vegetables and fruits; fats, oils; sugars and eets.

To plan a food budget for a family of a certain size it is necessary add together the estimated quantities needed for each family mem- r (Appendix Tables, A-7, A-8, A-9). For example, a food plan for week for a family group composed of a man and a woman each 33 ars of age, a girl 8, and a boy 11, would be as summarized in Table .

Table 36. Food Budget for a Family of Four for One Week

Food groups		Low-cost plan	Moderate-cost plan	Liberal-plan
ilk, milk products	qts	19.0	19.5	20.5
eat, poultry, fish	lbs	10.5	16.8	19.2
gs	no.	23.0	27.0	27.0
y beans, peas, nuts	lb	1.2	0.8	0.7
ain products	lb	12.0	11.0	10.2
tatoes	lb	9.8	8.5	7.8
trus fruit, tomatoes	lb	8.5	10.0	11.8
ark green, deep yellow vegetables	lb	2.5	2.8	2.8
ther vegetables, fruits	lb	19.8	22.5	25.2
ts, oils	lb	2.0	2.6	2.6
gars, sweets	lb	2.9	3.8	4.5

From *Family Economics Rev.*, Oct. 1957, Institute of Home Economics, U.S. epartment of Agriculture, p. 3.

The student of nutrition is aware that merely planning for kinds nd amounts of food is not enough; the planning must be with knowl- dge of the food preferences of the family and the availability and

price of these foods in the community at that time. The budget p
allows for choice of foods within the commodity groups. Furt
adjustment can be made even between the groups with a knowle
of food values; for instance, potatoes could not substitute for e
nutritionally, but another serving of meat would substitute very w

The estimated cost of one week's food supply for a 4-mem
family with children of school age as of October 1958[1] was $24.00
the low-cost plan, $32.50 for the moderate-cost plan, and $37.00
the liberal plan.

It is gratifying that an adequate diet can be provided at differe
cost levels. The low-cost plan contains substantially more potat
and grain products. The lower-cost meat cuts can be used in t
limited-expense plan with the assurance that the nutritive value
equal to that of the higher priced cuts. The moderate-cost and libe
plans include more milk, eggs, meat, fruits, and vegetables. Mo
expensive items such as foods out of season and the more high
processed foods are allowed for in the moderate-cost and liberal pla

Food Values and Food Costs

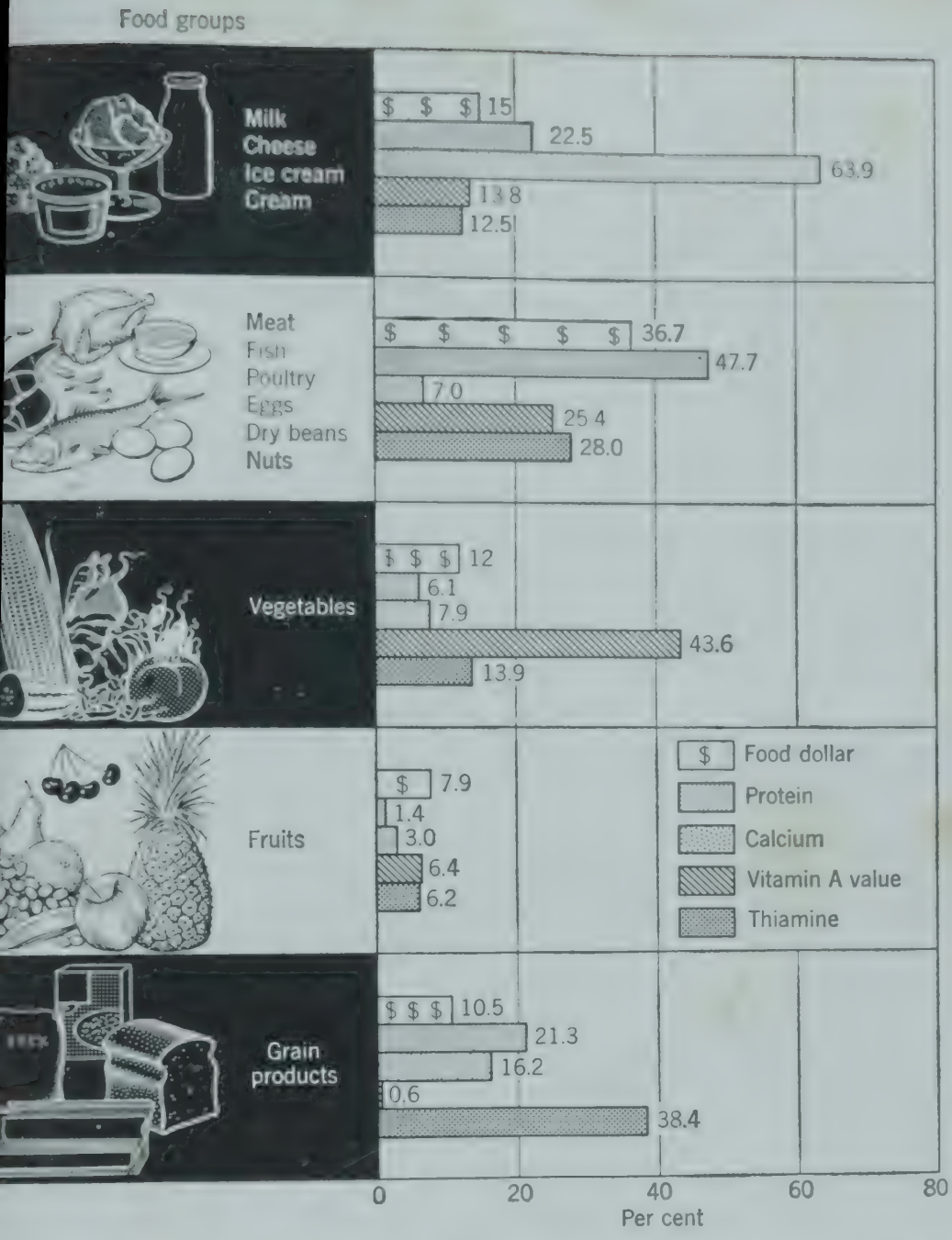
The expenditure for food is the largest single expense item in t
budget for most families. An average of 25 per cent of the incom
of the people as a whole is spent for food in the United States. Wi
increasing income, the per cent going for food diminishes. Data take
from the nationwide survey of food consumption made in the sprin
of 1955 show the shift downward in per cent of annual income e
pended for food with increase in income. The following selected da
are from city families.[2]

Low income group ($2000–$2999)	48 per cent family income
Median income group ($4000–$4999)	37 per cent family income
High income group ($6000–$7999)	29 per cent family income

Economical purchase of food makes it possible to provide adequat
diets at lower cost. Some nutrients are provided at less expense b
one food or group of foods than by others. The approximate per
centage of the food dollar spent for milk and milk products; mea
fish, poultry, eggs, dry beans, and nuts; vegetables; fruits; and grai

[1] *Family Economics Review.* Institute of Home Economics, U.S. Departmen
of Agriculture, December, 1958.

[2] *Dietary Levels of Households in the United States.* Report No. 6, U.S. D
partment of Agriculture, 1957, p. 60.



. 96. Per cent of food dollar spent for each food group and per cent of al protein, calcium, vitamin A, and thiamine supply provided by each group. ts and oils (4.4 per cent of money value), sugars and sweets (4.9 per cent money value), and miscellaneous foods (7.6 per cent of money value) com- te the remainder of the food groups. They were not included because of the al contributions made to the nutrients, except for the fats that account for per cent of vitamin A. (Adapted from *Dietary Levels of Households in the nited States*. Report No. 6, U.S. Department of Agriculture, p. 24, 1957.)

products is shown in Fig. 96. Other foods not included in F
96 are fats, sugar, and sweets, and miscellaneous items, which acco
for about 20 per cent of the total food expenditure. The prot
group of foods is the most expensive, amounting to 37 cents of
food dollar or 37 per cent of the food expenditure if we wish to th
of it that way. Milk and milk products account for 15 cents of
food dollar, vegetables 12 cents, grain products 11 cents, and fr
8 cents.

Foods differ in the economy with which they provide the nutrie
of the diet. Protein, calcium, vitamin A value, and thiamine we
selected to illustrate this point. Using Fig. 96 as a guide, in each fo
group if the nutrient bar exceeds the cost bar in length, that fo
group is a good buy for providing that nutrient, because the per ce
of the expenditure for that group of foods is less than the per cent
the nutrient obtained. The relative lengths of the bars will va
with price, of course.

It can be clearly seen that the milk group of foods is an excelle
buy for calcium, fair for supplying thiamine; the meat, fish, poultr
eggs, dry beans, and nuts group is a good buy for protein but
poor buy for calcium; vegetables are excellent for vitamin A, po
for protein; fruits are not a good buy for the nutrients listed, b
had ascorbic acid been selected as one of the nutrients in the illustr
tion, fruits would appear as a good buy for that nutrient.

Grain products are a good buy for protein and thiamine, and it ma
be surprising to note, for calcium, accounted for in part by the u
of bread containing nonfat milk solids. Of course, little if any vitami
A value is furnished by grain products. The protein of cereals
economical to purchase and becomes of good nutritional quality whe
supplemented with milk or other sources of complete protein.

Additives to Foods

When considering the foods available for use, the discussion is no
complete unless we examine the issue of *food additives*. Many of th
food products on the market today have had chemicals added to them
Although some of the substances are introduced intentionally for th
purpose of improving the nutritive value or quality of the produc
others are present as a residue remaining in the food after havin
been added at some stage of production or manufacture. The pres
ence of the latter type of substance in the final product is simply in
cidental and may or may not be desirable.

itives to improve nutritive value

limited number of foods have had nutrients added to them to rove the nutritive value. The addition of iodine to salt in 1924 the first important addition of an essential nutrient to a staple cle of food for nutritional purposes. Increasing the vitamin D con- of milk by adding irradiated ergosterol was a second milestone. lowing next was the enrichment of white flour and bread which an in the United States on a voluntary basis in 1941 with the ition of specified amounts of thiamine, riboflavin, niacin, and iron. the addition of specified amounts of vitamin D and calcium ional (2, 8). In 1947 standards for the enrichment of corn meal corn grits with the same nutrients as are in the wheat products re established by the Food and Drug Administration. More re- tly, rice also is being enriched. Margarine may be fortified h vitamin A; if represented as containing the vitamin, the con- tration must be 15,000 I.U. of the vitamin per pound which equals estimated average vitamin A potency of butter.

The introduction of the specified additives to the respective foods the approval of nutritionists and persons concerned with the health well-being of the populace. These nutrients had been found to deficient in the diets of the general population or in segments of it, ich prompted the addition of them to the respective foods. The neficial effects realized by the consumption of foods enhanced in tritive value through additives are discussed in the chapters devoted the respective nutrients.

We should bear in mind that bolstering the nutritive value of staple ods, beneficial as it may be, is not a substitute for education in the per choice and preparation of foods. It is wise to continuously rt effort toward improving methods of production, processing, and rage, attempting to preserve more fully the nutrients present in the ive products.

The common viewpoint of the Food and Nutrition Board of the tional Research Council and the Council on Foods and Nutrition the American Medical Association on additives to improve the tritive value of foods is set forth here in an abbreviated form (7). e requirements they set forth for the endorsement of the addition a specific nutrient to a particular food are as follows:

(*a*) A clear indication of the probable advantage of the increased intake the nutrient, (*b*) assurance that the food item concerned would be an ective vehicle of distribution for the nutrient that is to be added, and

(*c*) evidence that such an addition would not be prejudicial to the achie ment of a diet good in other respects.

Additives to improve the quality of products

The more complicated our processing of foods, the greater is t need for additives. More and more foods appear on the market w built-in preparation. For highly processed foods to be acceptab in keeping quality, flavor, and standard characteristics, the additi of certain chemicals has been necessary. For example:

Ascorbic acid is added to some fruit to prevent browning in free ing; sulfur dioxide is added to dried apricots and apples to preve discoloration.

Emulsifiers are added to shortening products to improve the leave ing and shortening power when used in bread, cakes, rolls, and oth products; calcium and sodium proprionate are added to bread a cake to prevent mold formation.

Antioxidants are added to fats to delay the onset of rancidit calcium salts are added to tomatoes so that they will hold their shap oxidants are used to help age flour.

Flavoring substances are added to improve the taste.

Coloring matter is added to improve the appearance.

This is not an exhaustive list, even though extensive, of chemica added to foods to improve the quality of the products themselves f the use for which they are intended. The additive may extend t period of time the product retains its freshness, enhance the color the flavor, or insure a product of more acceptability to the consum (*3*, *6*, *9*). These additives are introduced with no concern f nutritive value, but only for quality of the product, which of cour influences the consumer's choice in the market place.

Incidental additives

Incidental additives are chemical residues in foods. They a chemical substances that remain after having been added at some stag of the production or manufacture of the product.

Pesticides are a common source of such residues. It is necessar that pests be controlled, otherwise the food, particularly fruits an vegetables, would not be normal in physical appearance and quality and, furthermore, the size of the crop would be reduced. Not onl must pesticides be used in commercial production but also in th home garden and orchard as well, if a crop is to be harvested. Mil

. may contain traces of certain chemicals used to spray the cows
control of flies.

t is a continuous challenge to develop pesticides that will control
ect invasion without introducing substances harmful to humans, or
least which would not be harmful in the amounts likely to be used
man. Despite the care of the producer and the manufacturer,
re is need for a guardian of the health of the public in this regard,
l that control resides in the Food and Drug Administration.

There are incidental additives that not only serve their purpose in
ilitating manufacture but also improve the food value of some of
products involved. In that category is lime (calcium hydroxide)
ich is used in the refinement of sugar from sugar cane. It is added
the purpose of precipitating substances, including the pectins, fats,
xes, mineral substances, and organic acids from the sugar cane juice.
lime remains in the pure sugar at the end of the refining process,
t it is present in molasses, an intermediary product, making it a
re nutritious food.

ntrol of additives to foods

Surveillance over chemical additives to foods on the market rests
th the Federal Food and Drug Administration. This agency, in
operation with the state administrations, is concerned that whole-
me food, of good nutritive quality, accurately labeled, be provided
r the public. The federal agency operates under the provisions of
e Food, Drug, and Cosmetic Act of 1938, which provided for the
omulgation of standards for certain foods, and for the labeling of
oducts for special dietary uses. The standard of identity for a
rticular food which includes a definition of the food and stipula-
ns as to kinds and amounts of ingredients permissible, as well as
ality of the product, is established and made effective only after
blic hearings, and after the proposed recommendations have been
blished to allow any who are interested to challenge their ac-
ptability as to accuracy, accomplishment of desired purpose, and
gality.

The control of chemical additives in foods concerns the consumer
, *6*, 7, *9*). Prior to the enactment of a much needed new law in
ptember 1958, the regulation of additives to foods was as follows:

(*a*) Those products for which standards had been established by
e Federal Food and Drug Administration could include only ad-
tives for which the safety had been established.

(*b*) Those products for which no standards had been promulgated

could include additives irrespective of whether or not the safety h
been tested.

(*c*) Only those additives were forbidden that had been proved
court to be deleterious to the health of persons consuming the produ

The new law requires that chemicals for use in processing food mu
be proved by the industry to be safe for that purpose *before* th
can be sold. The manufacturer or promoter of a new food additi
must test it for safety on animals and submit the results to the Foo
and Drug Administration. If the Food and Drug Administration
satisfied as to the safety of the additive, it will issue a regulatio
specifying the amount which may be used, the foods in which it ma
be used, and any other necessary conditions of use. If the safety
the additive is not established in the opinion of the Food and Dru
Administration, its use will be prohibited.

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HAPTER 19

How well do we eat?

Thus far we have discussed the nutrients necessary for an adequate t. Also, we have considered food plans for supplying a sufficient antity of the nutrients and of Calories to assure an adequate daily ake of each. Now we shall examine our food selection practices. ow well do college students in the United States and the people as a ole meet the recommendations for an adequate diet? How ade- ate is the food supply of the people of the world?

The Eating Habits of College Students

Certain general patterns of food selection are found to characterize e diets of college students (*1*, *4–8*, *10*, *11*). Recent surveys (1950–57) show that as a rule certain nutrients are more generously pplied in the diets than others. Another feature that invariably aracterizes the habits of college students is the selection of better ets by men than by women.

Protein and niacin are the nutrients more generously supplied, as a le, than any of the others, reflecting an adequate use of foods in the eat, fish, and poultry group; on the other hand, calcium, ascorbic id, and vitamin A usually meet the Recommended Allowances least

well. Such shortcomings in the diet indicate that the students we using less than desirable amounts of milk and milk products, foods the citrus fruit and tomato group, and leafy green and yellow vege tables. The thiamine intake is influenced to considerable exte by the caloric value of the diet; students whose diets contain less th recommended energy intakes generally have less than recommende thiamine intakes also.

Nutritionists at the University of Rhode Island wished to kno why the ascorbic acid content of the diets of the coeds whom the were observing at that institution failed so frequently to meet th NRC recommendations—more often than any other nutrient with th exception of iron. They found on investigation that the supply o ascorbic acid available to the students in the dormitory fare w adequate, if from the fruits provided for breakfast they chose a citru rather than another fruit. Seldom did the intake of ascorbic aci meet the Recommended Allowance if citrus fruit was not eaten durin the day (*6*).

College men eat better diets than college women in terms of meetin the Recommended Allowances (Fig. 97). There is seldom a devi tion from this pattern in all of the survey studies. Men use more mil and milk products and as a consequence, have a more satisfactory ca cium and riboflavin intake than women. Ascorbic acid is less we supplied in the diets of women than of men. Most men have an ac ceptable intake of iron; many women do not. Recent diet record show as many as 36 to 42 per cent of the diets of college women pro vide *less* than two-thirds of the Recommended Allowance for iron The unfortunate circumstance in this shortage of iron in the diets o young women is that they urgently need this mineral to take care o the continuing loss of iron through menstruation.

Breakfast skipping or the consumption of an incomplete breakfast i reflected in the total nutrient intake for the day. Observations o students at Montana State College who omitted breakfast or ate one that failed to meet the meal pattern of a fruit, a cereal, and egg and/or meat, had a less adequate total nutrient content in the day' diet than those who did eat the complete breakfast. The missing nutrients as a result of no morning meal, or a poor one, were no made up in the later meals of the day (*5*). (For further discussion o breakfasts see Chapter 23.)

Food Consumption of Families

In the spring of 1955, a nationwide survey of the food consumption of families in this country was made by the Household Economic

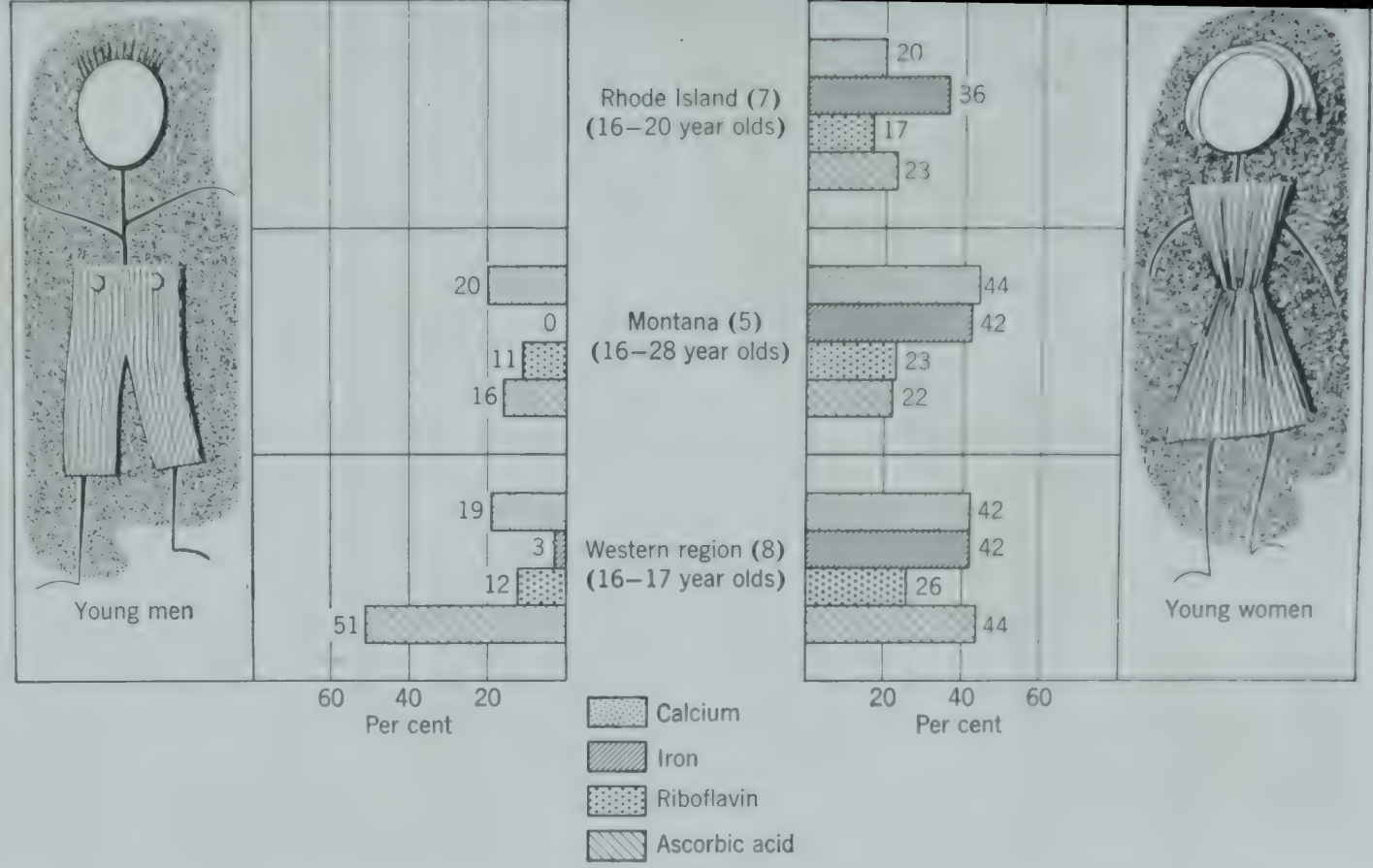


Fig. 97. Percentage of students whose mean intake of calcium, iron, riboflavin, and ascorbic acid was less than two-thirds the NRC Recommended Allowance (1948).

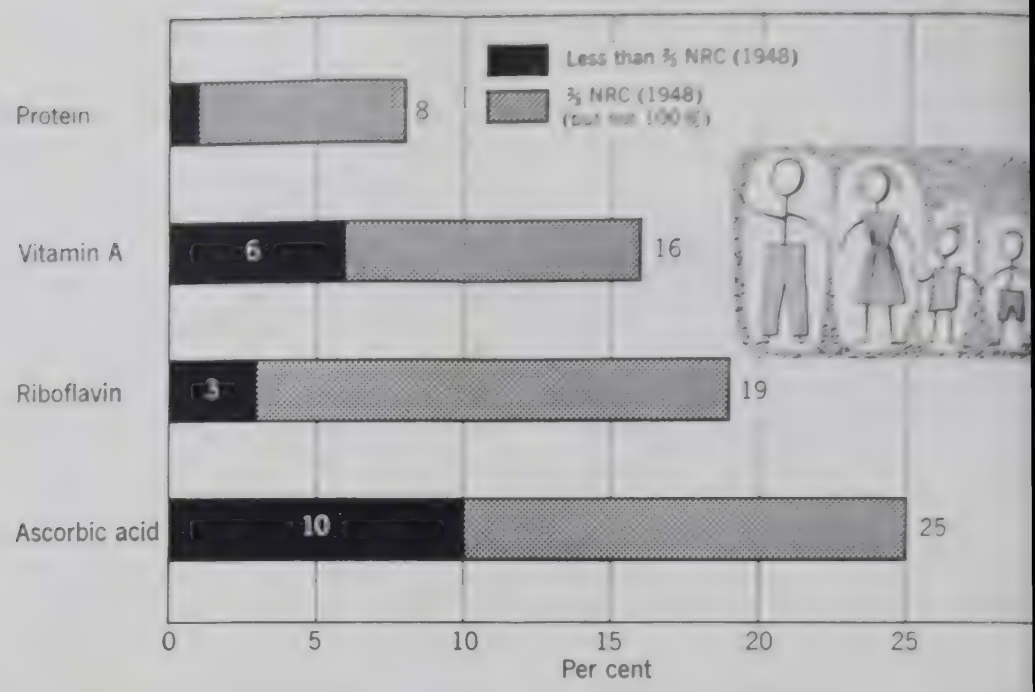


Fig. 98. Family diets not meeting selected NRC Recommended Allowan (Adapted from Clark, *Nutrition Education Conference.* U.S. Department Agriculture, Misc. Publ. 745, 1957, p. 9.)

Research Division and the Market Development Branch of the U Department of Agriculture (*2*). Families were interviewed by train workers to obtain information on the food practices of the fami The survey was the most comprehensive to have been undertaken this country up to that time.

The findings from this survey are representative of the food habits our nation at a time when it was enjoying an abundant supply of fo and full employment. The markets offered a variety of produc at various stages of preparation for table use, and at a wide ran of prices. On the whole, the nutritive value of the diets was goo The adequacy of the food consumed reflected in some ways t general high level of purchasing power among families. Protein a niacin were most adequately provided, indicating a good supply foods from the meat group of commodities (Fig. 98). Howev even with the abundant supply of food and the ability to buy t foods of choice in most cases, some nutrients were still inadequate supplied in family diets. Calcium and ascorbic acid were mo commonly supplied in less than recommended amounts.

There were differences in the food consumption patterns a adequacy of the diets of families over the nation. Diversity w

d to place of dwelling—whether urban or farm, to family in-
, and to family size. How families eat is found to be related
to the homemaker's preparation for the responsibility, her
tional knowledge, and also her level of educational attainment.

ence of urban or rural living

rm families were found to have a higher energy intake than non-
families, accounted for most likely by the outdoor physical
r of farm family members and the abundant supply of home pro-
d foods. When the value of the home produced foods was
ated at the price the family would have to pay for the same
on the market, it amounted on an average to around 40 per cent
he total cost of the food consumed. It should be noted that at
time of this survey, the farm family was producing less of their
food than in previous periods when surveys were made, reflect-
a trend in the farm family food supply. During the depression
he thirties and the war time of the forties, home gardens were
erative for food supply, in contrast to the abundance of food when
1955 survey was made. The chief differences between the urban
farm family diets in the kinds of foods consumed was the use
greater quantities of grains, sugars, and fats by farm families and
tively less meat, as shown in Fig. 99.

uence of income

ll surveys of food consumption practices show a definite rela-
ship between the income of the family and the amount expended
food. As the income goes up the amount of money spent for
d increases but at a proportionately slower rate, so that the *per*
t of the income going for food decreases. High-income families
nd a lesser per cent for food than those with lower incomes. Some
he increase in expenditure at higher income levels goes for larger
ntities of foods; much of it goes for increased services in the form
oods requiring less preparation time by the homemaker, as well as
purchase of meals away from home.
amilies with more money to spend tend to choose more costly
ds within a food group. For example, families with an annual
me between $2,000 and $3,000 paid, on the average, 56 cents a
nd for meat, those with incomes from $4,000 to $6,000 paid 62
ts, and the families with a $6,000 to $8,000 annual income spent 66
ts. The cheaper cuts of meat were used by low income families;
k (other than round) appeared on the menu during the week in 24

Families

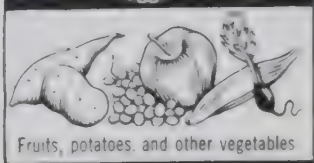
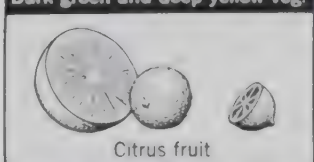
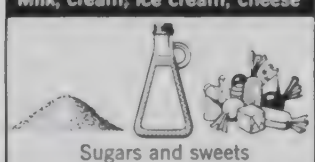
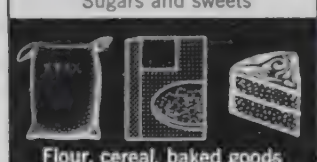
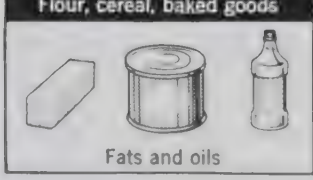
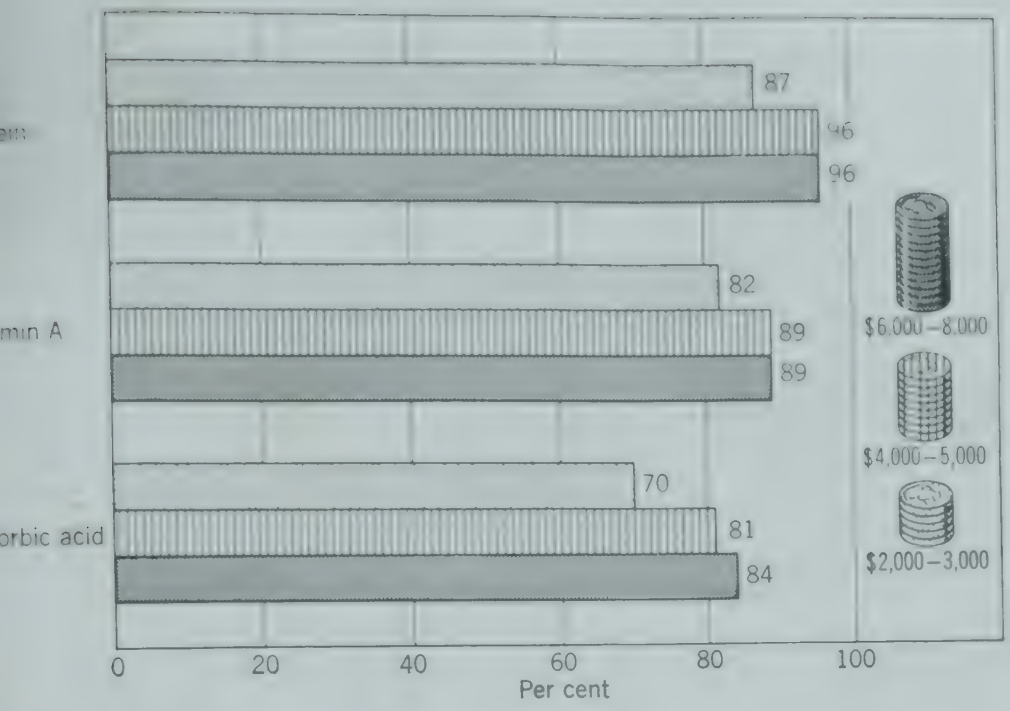
	Measure	Urban	Rural non-farm	Fa
 Meat, poultry, and fish	lb	4.4	3.8	3.8
 Eggs	doz	0.6	0.6	0.7
 Fruits, potatoes, and other vegetables	lb	10.2	9.6	9.6
 Dark green and deep yellow veg.	lb	0.6	0.4	0.4
 Citrus fruit	qt	0.6	0.5	0.4
 Milk, cream, ice cream, cheese	qt	4.3	4.4	5.2
 Sugars and sweets	lb	1.1	1.3	1.8
 Flour, cereal, baked goods	lb	2.6	3.3	3.9
 Fats and oils	lb	0.8	0.9	1.1

Fig. 99. Comparison of urban, rural non-farm, and farm family diets. Quantities per person for one week. (Adapted from Food Consumption and Dietary Levels, U.S. Department Agriculture ARS 62-6, 1957, p. 3.)



100. Income and per cent of city families meeting the NRC Recommended owances for selected nutrients. (Adapted from Clark, *Nutrition Education ference*. U.S. Department of Agriculture, Misc. Publ. 745, p. 15, 1957.)

cent of the low-income families, and in 37 and 44 per cent re- ctively of the medium and high-income households (2).

The adequacy of the diet improves with increase in income. tamin A, riboflavin, and ascorbic acid, selected as representative of diet as a whole, increased in adequacy as the income increased ig. 100). It is true that spending more money for food *tends* to ovide a better diet, but not to assure it. Some of the families with omes in the top third failed to meet the NRC recommendations ig. 101). Most of the diets of these high-income families provided fficient protein and niacin, but as many as 23 per cent failed to pply the recommended amount of calcium.

luence of family size

The 1955 survey confirmed the already well-established relation- ip that large families spend more for food in total, but the amount pended for each family member is less than in small families. To ustrate, city families in the income bracket of $4,000 to $4,999, with e number in the family increasing from two to six, were selected. he greater the expenditure for food in terms of per cent of income

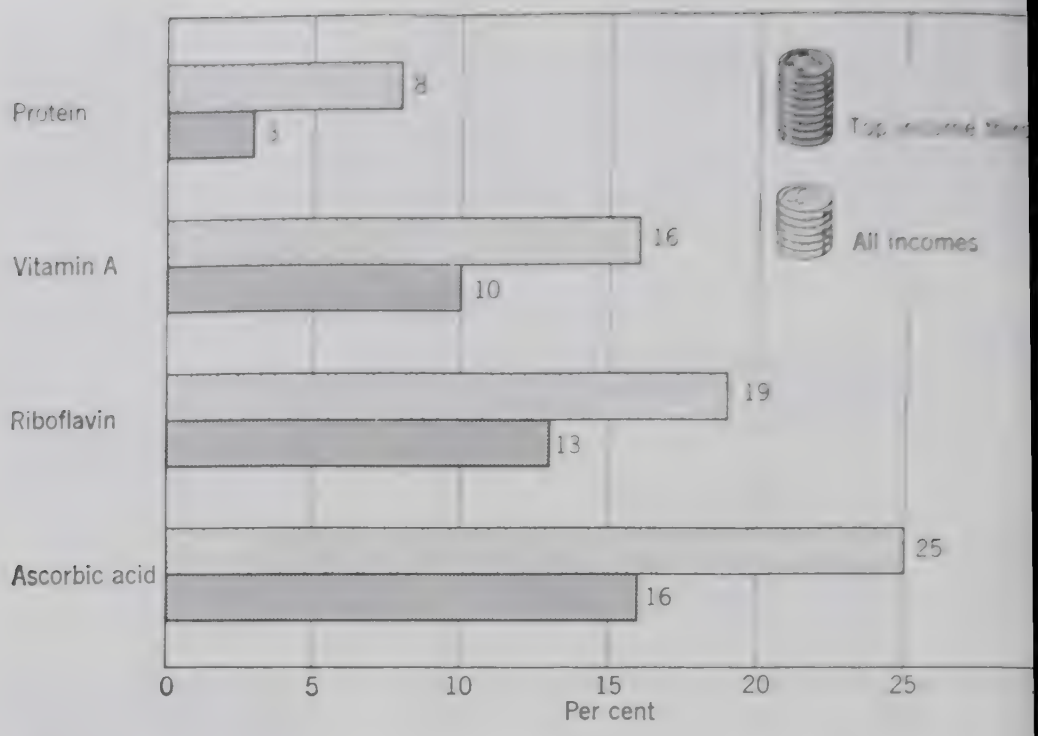


Fig. 101. Family diets not meeting NRC Recommended Allowances in top come third and all incomes. Money alone will not provide a good d (Adapted from Clark, *Nutrition Education Conference*, U.S. Department Agriculture, Misc. Publ. 745, p. 16, 1957.)

and the decreasing money value of the food for each person as t number in the family increases, are shown in Fig. 102.

There are some explanations for the smaller expenditure per pers in larger families. It is possible, as a rule, to prepare food mo economically for a large number of persons. Also, in large famili there are usually small children who require less of some of the foo Furthermore, the quantities of foods, especially those that are high in price, are used more sparingly in the larger households than the small. This follows as a consequence of the usual smaller incon per capita in large families.

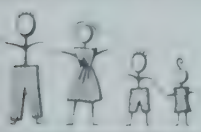
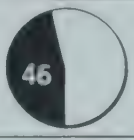
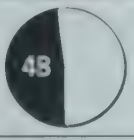
Influence of homemaker's nutritional knowledge and educational lev

In a study of "what homemakers know about nutrition," conducte by nutritionists at Cornell University (*9*), a higher percentage those who had what the investigators termed a *minimal* knowledge nutrition fed their families adequate diets than the homemakers wh had only *some* or *no* knowledge. Minimal knowledge was defin as the "ability to give a correct reason for the inclusion of at lea

e of the seven basic food groups." Educational level of the home er also showed a relationship to the adequacy of the diets of families. Homemakers who had graduated from high school better practices than those who had not completed high school. they in turn succeeded in feeding their families more adequately those who had had only a grade school education.

Food Consumption of Individual Family Members

Within the family group some members fare better than others in adequacy of their diets. Boys and men consume relatively better s than the girls and women as a general rule. These data from udy in Groton Township, New York, illustrate the common ern of food selection within a family group. As a whole, the ng children (age groups under 10 years) fare best, followed next the rest of the male members of the family. The least adequate s were among the adolescent girls and women of childbearing (*12*).

Number of family members	Percent of income spent for food	Money value of food per person (basis of 1 week)
		$11.54
		10.30
		8.74
		8.20
		7.10

102. Influence of family size on per cent of income spent for food and ey value of food per person. (Adapted from Food Consumption and Dietary els, U.S. Department of Agriculture ARS 62-6, p. 8, 1957.)

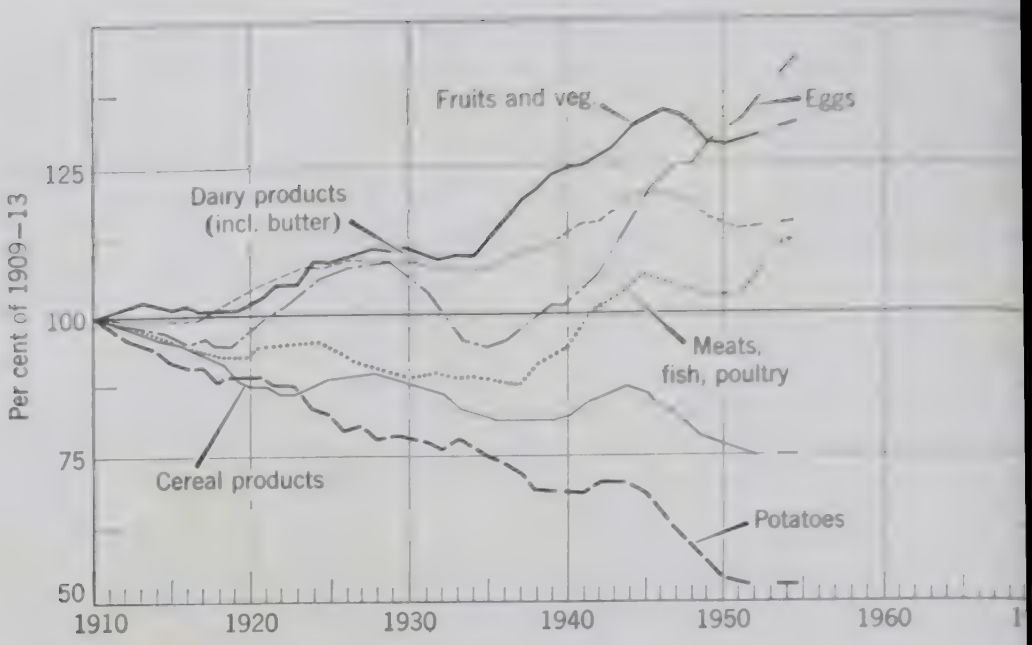


Fig. 103. Trends in our eating habits. Per capita civilian consumption in United States. (The five-year moving average is centered for plotting. year 1954 is shown by symbols.) From *Guide to Agriculture*, U.S. Departm of Agriculture, Bull. 30, 1955.)

Trends in Food Habits in the United States

The food consumption in this country, from 1910 when the fi official records were kept to the present time, show certain gene trends in our eating habits (Fig. 103). The change has been towa an improved diet. The commodities that have shown a general u ward trend in per capita consumption are fruits, vegetables, and da products; those that have taken a downward trend are cereal produ and potatoes. It is the increased use of citrus fruits, tomatoes, a green and yellow vegetables that accounts for the decided upwa trend of fruits and vegetables. The consumption of meat and eg has been variable but since the depression of the mid-thirties h moved sharply upward.

Other People of the World

Through the Food and Agriculture Organization of the Unit Nations information is gathered on the supply of food for the peo of the world. There is not enough food at the time this is bei written, nor was there enough at the first meeting of FAO in 19 In the intervening years, the quantity of food produced has increas

the world population increased also. However, developments are
using. In 1945 food production per capita was not increasing
st as the population; by 1949 the relationship was reversed with
l production per capita in the lead and it is continuing so at this
ing (1958). Improved production within the countries and
er global distribution of food has contributed to the more favor-
supply. Much credit is due to the work of FAO in helping
member countries to improve their farming practices (3).
espite the remarkable progress that has been made, problems re-
n--of how to increase productivity, how to distribute the world's
l supply to avoid surpluses in one area and meager supplies in

Table 37. Number of Hours' Work Required for Average Factory Workers to Earn the Cost of Three Representative Meals for One Person for One Day

	Diet A	Diet B	Diet C
Calorie value of diet	2100	2500	3000
Grams of animal protein	10–12	15–20	40–45
COUNTRY		HOURS OF WORK	
India	2.1	2.9	4.5
Japan	1.8	2.3	3.8
Italy	1.1	1.5	3.2
Mexico	0.6	0.8	1.4
Sweden	0.4	0.6	0.9
Denmark	0.3	0.4	0.7
Canada	0.2	0.3	0.5
United States	0.2	0.2	0.4

rom *The State of Food and Agriculture*, 1957, Food and Agr. Org., Rome, Italy, 08.

ther, how to know what foods are needed and how much. ere is a further problem with which the FAO workers must cope, t is breaking through the traditions that are firmly established ough years without change to persuade adoption of new and better thods of production and better use of the natural resources.

The cost of food in relation to income is a barrier to attaining a diet t meets a satisfactory nutritional level. In order to compare the t of food relative to income in different countries, FAO has esti- ted the income on the basis of the number of hours required for average factory workers to earn the cost of three diets with dif- ent caloric value and animal protein content. In Table 37, Diet A

is representative of diets in economically underdeveloped coun
Diet B is representative of the diets in countries at early stages of
dustrialization; Diet C is representative of diets in economically
vanced countries. Each set of diets contains the foods customa
used in the respective countries, and the cost is based on price
those countries also. Even small increases in income are reflecte
improved diets among the most deprived. It should be pointed
that whereas Diet A needs improvement, it is folly to hope or to
for diet C for the people of the world. On the other hand, i
reasonable to plan for an improved diet.

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HAPTER 20

Good and poor nutrition

The physical well-being of an individual is related closely to his us of nutrition. Furnishing adequate food to a well-functioning ly assures good nutrition. On the other hand, poor nutrition nes about from an inadequate food intake, or a failure of the body use efficiently the nutrients supplied to it.

Malnutrition is not a simple syndrome. The poorly nourished in-idual, as a rule, suffers from a complexity of deficiencies. The at diversity of body functions that may be ill-affected by inade-ate nutrition complicates the process of assessing nutritional status.

Methods of Assessing Nutritional Status

The appearance of an individual gives some indication of his state nutrition even to the untrained eye. Underweight and overweight ividuals are readily recognized. A child who is the "picture of lth" or one who is pale and listless can be easily identified by those o are in any way sensitive to the health of children.

For a more refined diagnosis one or all of the following three pro-ures may be used: (1) clinical observations, (2) physical measure-nts, and (3) laboratory analyses (*21*). In assessing nutritional us, the methods of choice are determined by the purpose for which observations are being made, and the personnel and funds available carrying on the work. In conjunction with the assessment of ritional status, a dietary history of usual food practices, together h those currently followed, permits a more advised interpretation findings.



Fig. 104. A well nourished 5 year old.

Clinical signs as a means of assessing nutritional status

The appearance and behavior of an individual are useful guides evaluating state of nutrition (22). Nurses, nutritionists, teachers, a parents, in fact, all who are associated with children, should familiari themselves with signs of good nutrition and, even more particularl evidences of nutritional failure. A periodical examination by a phys cian helps in the detection of incipient undernutrition in children.

Characteristics of a well-nourished person

General appearance of vitality and well-being, eyes are clear an bright with no dark circles beneath them; hair is smooth and glossy.

Skeleton is sturdy; strong, straight arms and legs, well-shaped hea and chest; sound, well-formed teeth, set in well-shaped jaws, goo occlusion, healthy gums.

Muscles well developed and strong, with proper balance of variou muscles; posture generally erect.

Subcutaneous fat sufficient to make a moderate padding over th skeleton and muscles, giving the body a well-rounded contour.

dy functions related to nutrition proceed normally; good appe- and digestion, regular elimination; sleep sound and refreshing; le nervous system; good endurance, prompt and adequate recovery n fatigue.

racteristics of a poorly-nourished person

oes not have the appearance and buoyance of physical well being. acks some or all of the characteristics of the well-nourished person. lyperirritable and unhappy, with a strained, tense attitude espe- ly when underweight.

ven though lacking in physical endurance, often hyperactive when erweight.

ymptoms of poor nutrition due to an insufficiency of certain nutri- in the diet are described in the chapters devoted to essential die- components.

sical measurements as a means of assessing nutritional status

During childhood acceptable growth is a pretty good index of us of nutrition. Physical measurements of individual children to ermine their growth is the most widely used method for assessing ritional status. Body weight and height are the measurements most



105. A 5-year old showing nptoms of undernutrition.

commonly made; children are weighed and measured at school, home and at the physician's office. Adults, too, tend to follow the weight closely. Weight-height measurements have the distinct advantage of being easily and quickly made. Certain precautions must be taken, however, in order that the measurements be as accurate as possible if they are to be meaningful. The following suggestions will help to reduce the error in determining body weight if followed closely: weigh (1) wearing the same amount of clothing at each weighing, (2) after emptying the bladder and without a recent drink and (3) an hour or so after a meal. An accurate scale should be used. Certain precautions should be taken in measuring height also. The stance makes a difference. For the measurement, the subject should stand with back against a flat surface, such as a wall or a measuring board on which a tape has been attached. With heels together, and against the flat surface, the individual is asked to "stand straight." By placing a board, prepared for this purpose, on his head, parallel to the floor, the height can be read from the tape. There is a tendency for all of us, both young and old, to slump a bit with the progress of the day. It is more pronounced on some days than others and is related to a considerable degree to status of fatigue. As a consequence, repeated measurements taken following the reminder "to stand straight" give values that agree more closely than those taken without directions given as to stance.

Physical measurements, repeated at intervals, give a picture of the pattern of growth of the individual child. Each grows at his own rate and in a fashion peculiar to himself, influenced both by his inheritance and the environment in which he lives (*16*). Despite the marked differences in growth behavior among individual children there is a common, all-over pattern that all children seem to follow more or less closely.

The general trend of growth from birth to maturity assumes an S curve representing four different phases, characterized by the rate at which growth is proceeding. The first phase is one of rapid growth extending from birth through the first year. This is followed by a period of slower growth covering the years from early childhood to around 12 years of age. The third phase is another period of accelerated growth, beginning with the preadolescent "spurt," reaching a peak at about the thirteenth year for girls, and the fifteenth for boys. The last phase is one of decline in rate as adulthood is approached (Fig. 106).

Valuable as height-weight measurements are in following the growth of individual children, sometimes they are misused. When

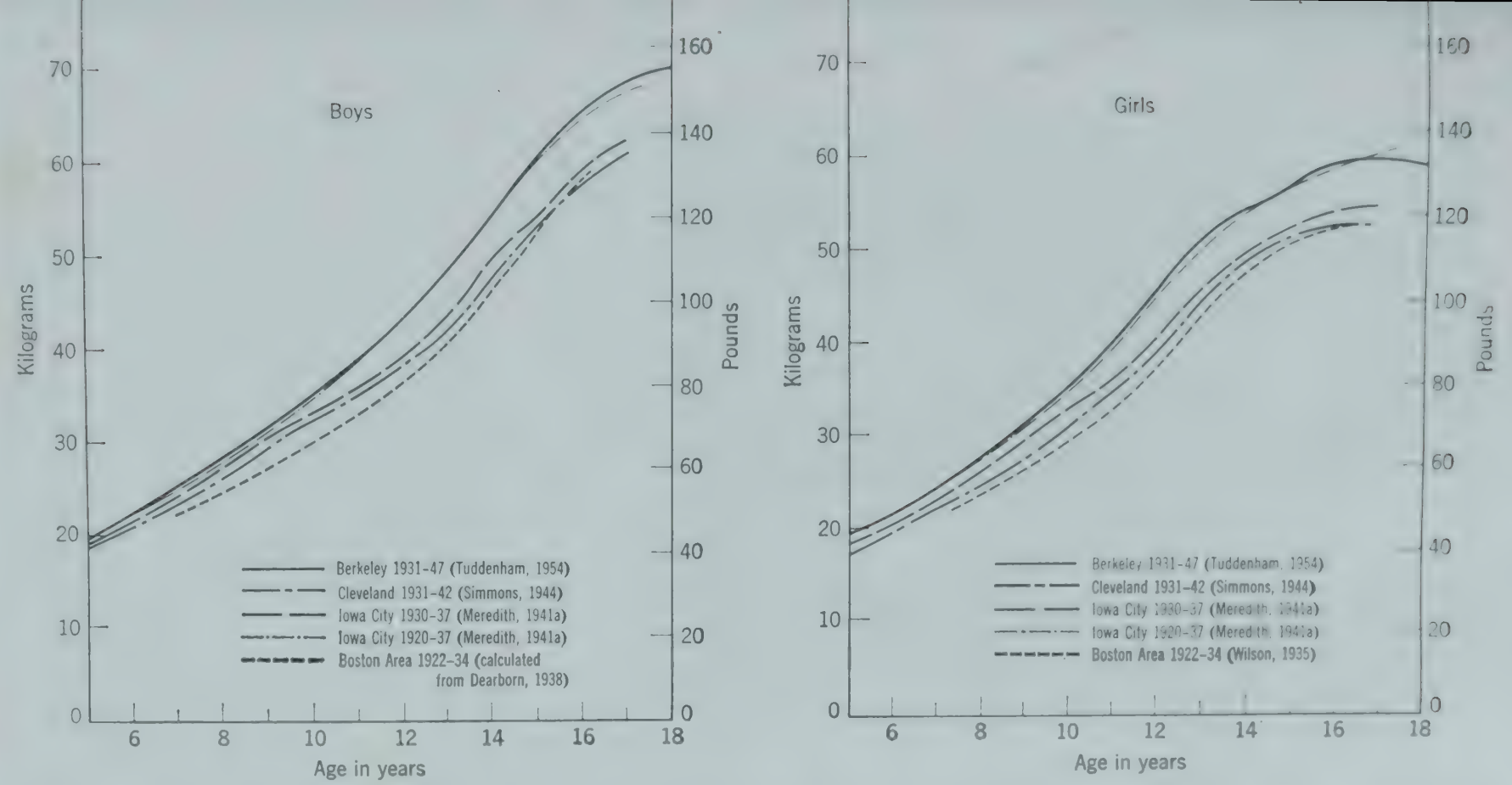


Fig. 106. The growth pattern of boys and girls. (Courtesy Hathaway, *Home Economics Res.* Report No. 2. U.S. Department of Agriculture, p. 104, 1957.)



Fig. 107. Three 8-year-old girls of different body builds and size. (Courte
Agr. Res. Service. U.S. Department of Agriculture.)

child is expected to meet the size recorded in standard height-weigh
age tables, we believe that his measurements are being misused. I
the past the custom of using deviations from the tables in body weigh
as criteria for judging under- or overnutrition was more prevalen
than it is today. It is apparent to those who really understand th
it is not reasonable to expect children of the same age to be the san
weight (Fig. 107). There are inherent factors of difference. One o
the most significant is that of body build. Not only does the heigh
of an individual make a difference in body weight but also the widt
of the hips, the breadth of the shoulders, and the size of the bon
affect the weight.

It is now generally recognized that if the growth of a child is to b
related to a standard, that standard must make allowances for diffe
ences in body build. Several such procedures have been developed

wing for variable heights and weights at each age level. Meredith), at the University of Iowa, established standards of reference from measurements of Iowa children, with five zones of height and five es of weight for each age from 4 to 18 years. The descriptive ns applied to zones of height are *tall*, *moderately tall*, *average*, *derately short*, and *short*. For weight they are *heavy*, *moderately vy*, *average*, *moderately light*, and *light*. Charts bearing the zones height and weight for age make it possible to plot the height and ght of individual children and then to follow visually the growth tern (Fig. 108). The chart gives an indication of body build. For mple, if the child's height for age falls in the short zone, it means is short for his age; if his weight falls in the average zone, it means is of average body weight for his age, and so on. Meredith ex- ins that in using the physical growth chart, "the relation of an ividual's height and weight curves to the appropriate normative ves gives information on satisfactoriness of growth. Downward s, plateaus, or sharp upward turns indicate probable need of med- l attention."

Another procedure for following the development of children was roduced by Wetzel (*32*). His method, too, is graphic, employing chart known as the *Wetzel Grid*. There are three panels on the art, one locates the child as to body build, another includes his ysical development in relation to his chronological age, and the rd, designated as the energy panel, relates to the basal heat pro- ction and energy need of the child.

boratory analyses as a means of assessing nutritional status

The laboratory method of assessing nutritional status is relatively ore sensitive than the other two methods (recognition of clinical ns and physical measurements), particularly in detecting early evi- nces of poor nutrition. Chemical determinations of the composi- n of the blood and urine, microscopic examination of the blood, d x-ray photographs of the bones and teeth are among the labora- y procedures used in assessing nutritional status by this general thod. Alterations from the accepted range of values forewarn of nditions which, if not checked, may cause a stunting of growth d other symptoms of malnutrition apparent to the naked eye.

There are certain limitations to the widespread use of laboratory alyses as a means of assessing nutritional status. The techniques de- nd trained personnel, the procedures are lengthy, and the cost ost prohibitive for routine use. As a consequence, this method is nfined chiefly to use in medical clinics and in research studies.

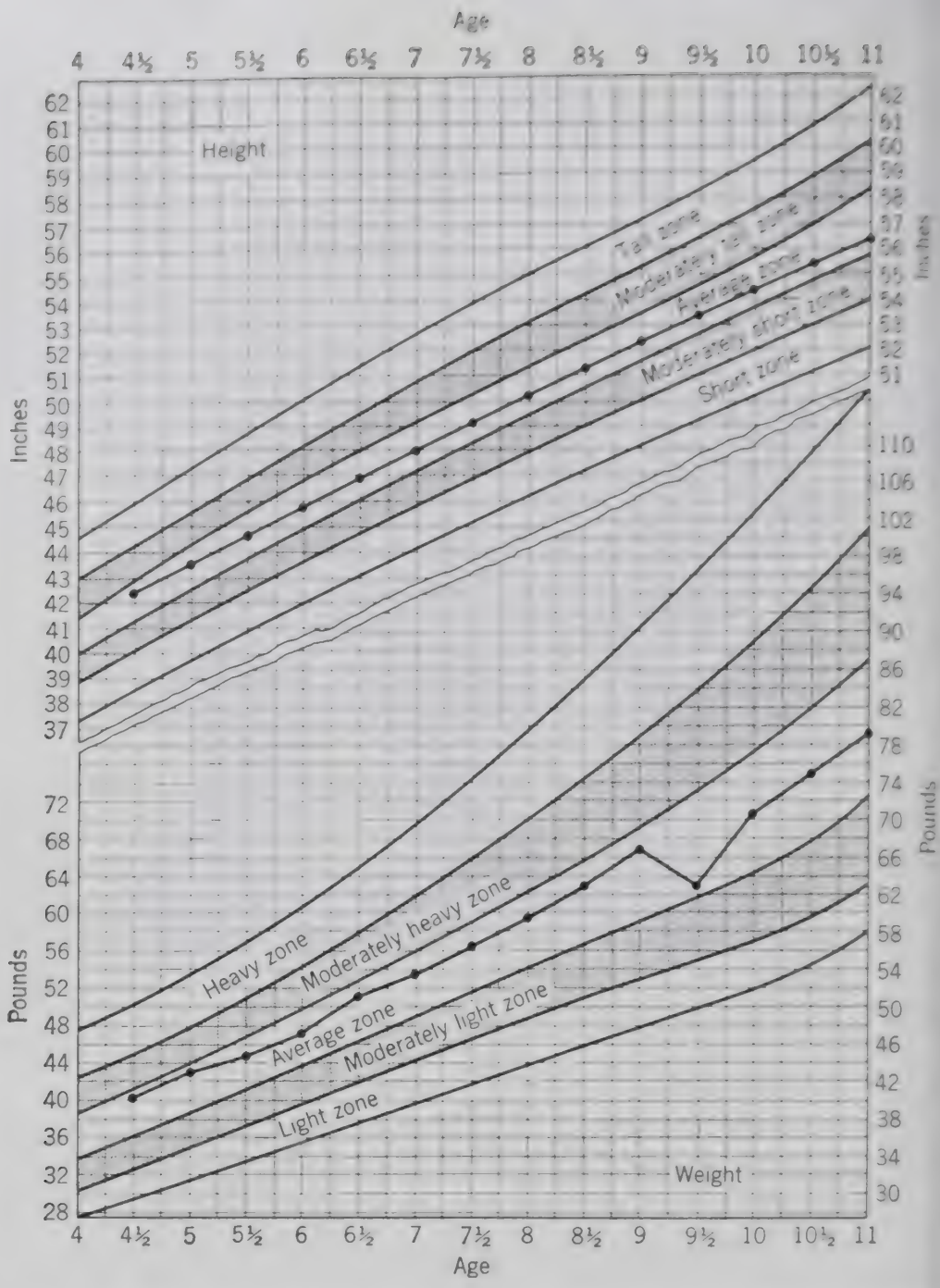


Fig. 108. Meredith physical growth chart for recording the growth in heigh and weight. The record reproduced on the chart is based on actual height an weight measurements provided by Dr. Meredith. In using the chart—to plot th height status, find the age across the top, the height along the upper left han margin, locating the dot on the chart at the intersection of imaginary lines ex tended from those points. For weight, find the age along the lower edge o the chart, weight along the lower left hand margin; locating the dot on th chart at the intersection of the imaginary lines. At 9½ years, Susan whose char this is, developed allergies and infected tonsils which apparently caused failure t gain in weight until she was successfully treated. (Courtesy of Mrs. Martin, an Dr. H. V. Meredith, permission the University of Chicago Press. From Martin Roberts' Nutrition Work with Children, p. 128 and 371.)

To illustrate the use of the laboratory method a research study of nutritional status of New Mexico adolescents is cited (*19*). The dy included analysis of the blood for certain constituents, among ich were: hemoglobin, serum protein, ascorbic acid, riboflavin, otene, and vitamin A. Average values for the group under study re determined for each of the constituents. Further use made the values is illustrated by selecting one constituent such as ascorbic d for discussion. The investigators found 51 per cent of the olescents to have serum ascorbic acid levels below 0.5 mg; levels ow 0.6 mg are usually considered borderline and 0.4 mg definitely normal. The "generally low" ascorbic acid values of the blood re found to be accompanied by a low ascorbic acid content of diet.

Certain of the common laboratory methods employed for detecting mptoms of an insufficiency of the individual dietary nutrients are ed in the preceding chapters devoted to the respective nutrients.

Dietary Studies and Their Use

Dietary studies provide a means of determining the kinds and nounts of foods eaten by individuals or groups. The information ay be a dietary history, that is, a record of foods usually eaten, or accounting of current food selection practices. The records may concise or they may be generalizations; they may be for a small mmunity or on a national or worldwide scale. The use to be made the findings dictates to considerable extent the methods to be used collecting the information.

Food consumption data serve widely divergent interests. For ef- ctive nutrition-education programs, a knowledge of the food habits the persons for whom the plans are being made is an essential pre- quisite. Nothing can be more irritating than to be advised to llow a practice that is already fully in effect. In conjunction with e assessment of nutritional status, a dietary history of the usual food actices, together with current variations, permits a more advised in- rpretation of the findings. We would conclude that a picture of od nutrition must reflect the consumption of an adequate diet. On e other hand, deviations from normal nutrition may be related to a nited diet or to an inefficient utilization of the nutrients supplied. s an aid to discerning which of the two may be the limiting factor, knowledge of the food habits in the situation is essential.

The food intake of individuals. For obtaining information on the od habits of individuals four different procedures or combinations

thereof are in common use (*4, 8, 9, 35*). They include (1) t
dietary history, (2) the 24-hour recall, (3) the dietary record, a
(4) weighed dietaries. The methods differ in the precision wi
which the records are obtained.

The dietary history yields information on the usual pattern of foo
consumption followed over a period of time. It is obtained by inte
view, as a rule. Burke, who developed the method and used it
successfully in the Harvard prenatal studies, has pointed out that t
person doing the interview is the key to success in taking the histor
The interviewer, she believes, must be a keen observer and must ha
a familiarity with the characteristic food habits of the group she
interviewing. The dietary history is used most commonly in re
search studies; long term food habits help to explain the current nutr
tional status of individuals.

The 24-hour recall is the most expedient method of obtaining info
mation on food eaten. It usually entails a brief interview in whic
the subject is asked to recall all food consumed during the last 24-hou
period, starting with the last meal or food eaten. The most commo
use for information obtained by this method is as the basis for educa
tional programs. In research studies that have involved the foo
habits of large numbers of individuals, the recall method has prove
to be both fairly quick and sufficiently accurate to be used with con
fidence.

In the food record procedure the individual keeps an account of th
kinds and amounts of all foods eaten for a specified period of time
The Northeast Regional Research group (*8*) found that a one-wee
record was sufficiently long to give representative information for us
as the basis for an educational program. Students in college, high
school students, even children in the elementary grades keep foo
records which serve as the basis for nutrition education with th
respective groups. For those who are attempting to reduce, a record
of everything eaten and a tally of the total Calorie intake has been
found to be an effective curb on the appetite. The days of the week
selected for the study are found to make a difference in the final re
sults; school children, and college students also, are found to ea
differently over the weekend than on other days of the week (*6, 10*).

A fourth method of determining the food intake of individuals is by
actually weighing all food eaten. This method is precise and ac
curate, but time consuming and expensive. As a consequence, it i
confined chiefly to research studies in which food samples representa
tive of that eaten are analyzed quantitatively in the laboratory fo
nutrient content.

he food intake of groups. Two methods commonly used for ob-ing information on the food habits of families and other groups the food-inventory method, and the food-list method.

n the food-inventory method all foods on hand are weighed at the inning and close of the study period, and a record is kept of all ds added to the supply during that time. From these records it ossible to determine by weight the amount of food used by the ily or institutional group. An estimate of waste must be made er by actual weight or by computing the inedible portion as indi-ed in food composition tables. The latter procedure does not e into account plate waste and spoilage. Corrections must be de for food eaten by guests and for meals eaten away by the study up. Menus used during the period of study are an added check the validity of the food records.

For the food-list method, an estimate of the quantities of food (by ight, retail unit, or household measure) used during a certain iod by the family or group is obtained. This method has the ad-ntage of requiring only a short visit of the worker, and much less the time of the group being studied than the inventory method. is not as accurate as the inventory procedure but gives an acceptable imate when an approximation is all that is desired.

The national average nutrient consumption per capita. Estimates of arly per capita consumption of various foods on a national basis derived from statistics of production, foreign trade, inventories on nd, industrial uses, feed, use and losses in distribution between farm d kitchen. Calculations on the nutrient content of the supplies ailable for human consumption are made, and the per capita value termined using census population figures. These values are in-ative of the relative adequacy of the national food supply. The r capita national averages are for the country as a whole and are of ue in indicating trends in food habits (7).

Methods of Determining Adequacy of Diets

The nutritive value of the food intake may be ascertained by nu-rous methods, varying from an approximation to precise labora-y analyses. As with the choice of the dietary study method, the oice of the evaluation procedure depends on the use to be made of findings and the accuracy with which the food consumption data re collected. Thus, precise methods of evaluation are used only th the food intakes that have been weighed accurately.

The procedures for evaluating diets include the use of dietary score

cards developed on the basis of food groups, the use of food compo tion tables by which the nutrient content and energy value of t diet can be computed, and last, laboratory analysis of aliquot portio of foods representative of the diet eaten. The first method provid only a rough approximation of the nutritive value of the diet, t food composition table is more accurate, and the analytical proced the most accurate. A more detailed discussion of these methods evaluation is found in Chapter 18 on "Selecting an Adequate Diet."

Falling Short of Good Nutrition

The problem of being overweight

Obesity is the most common deviation from normal nutriti among the adult population of this country today. One-fifth of group of 226,000 persons between the ages of 15 and 59 were fou to be overweight in a study done in 1954; 10 per cent were 20 p cent above the desired weight (*11*).

The terminology used to describe excess weight differentiates b tween "overweight" and "obesity." An individual whose weight 10 to 20 per cent above the "ideal" according to present weig tables[1] is considered overweight. Deviations of 20 per cent or mo above the desirable weight are recognized as pathologic and the co dition designated as obesity.

The discussion to follow is concerned chiefly with adults. Is pertinent to ask if children are ever overnourished? (*30*) The answ is that they are, often due simply to a good appetite, good food hig in nutritive value available, and a good digestive system to take ca of the quantity of food eaten. These overnourished children, a usually tall for their age and overweight for their height; they a well fed. On the other hand there are children who are obese a poorly nourished. Their diets have provided more than enoug energy but less than enough of some or all of the nutrients for goo nutrition. A matter of first concern is to provide for each child, f or thin, the needed nutrients (Chapter 23). Changing from a di poor in nutritive quality to one that is good may in itself cut dow on the consumption of extra "empty" Calories like excessive swee Eating the necessary foods to supply the nutrients in an adequa diet spends the appetite to some extent and helps to curtail the co sumption of empty-calorie foods.

[1] Tables in appendix. Desirable weights for men. Desirable weights f women.

actors contributing to the incidence of overweight. When asked
y the incidence of obesity is so high, some answer simply that it
he result of eating too much. That is true, and the answer is based
a fundamental law of science, the *Law of Conservation of Energy*.
ted in simple terms, the provisions of this law, which apply to the
rgy balance in any machine, are that energy cannot be created and
not be destroyed, but it can be changed from one form to another.
us in the case of the body as a machine, if the energy value of
food exceeds the Calorie expenditure for work and for heating the
dy, the remainder will be stored in the tissues as potential energy.
cause the body has a relatively limited capacity to store protein
d carbohydrate, the most of the excess is converted to fat and
red as such.

The question remains as to why people are impelled to eat more
od than is needed to supply the energy requirements of the body.
here are basic, underlying reasons responsible in the case of each
dividual. Among the contributing factors are disturbed appetite
ntrol, psychosomatic influences, lowered energy need with age,
sufficient physical exercise, the role of food in our social life, and
e habit of eating more food than is needed.

Disturbed appetite control. The primary motivations for excessive
ting are complex and as yet incompletely understood. We know
at appetite is the factor that compels people to eat. By definition,
petite means "desire for food." We can properly conclude that
cessive eating results from a disturbance in appetite control. It is
fficient to say that physiologists know that there are centers in the
ain that exert a control on appetite; also that pharmacologists and
ysicians know of drugs that curb the appetite. This approach to
petite control is still in the experimental stages.

Appetite as a function of the mind may influence us to eat when
e have no need for food. The kinds of foods that we desire are
ose that we have previously eaten and have enjoyed, or foods, al-
ough new to us, that look, smell, or taste like those we do enjoy.
'e have all been victims of tricks of our appetite. For instance, at
e end of a heavy meal we decline all proffered food on the basis of
eing full" until offered our favorite delicacy which we accept, eat,
d enjoy.

At times we feel the need of food and describe ourselves as "being
ngry." We do not desire any particular food, just something to
t. We may properly inquire if our physiological status at those
nes is responsible for the hunger sensation. There are several ex-
anatory theories; one widely accepted relates to the blood glucose

level (*24*). It operates in this manner: when the difference between the glucose content of the venous and arterial blood tends to lessen, as happens as time passes after a meal, hunger occurs. On the other hand, immediately following a meal with the absorption of glucose the difference widens and the desire to eat is normally absent.

At Cornell University twelve students whose weights remained constant normally were given a special liquid supplement of 1000 Cal. each night about 10 o'clock. The purpose of the investigation was to see if the body could control the appetite, automatically reducing the caloric intake at other times of day to make allowance for the extra calories in the supplement. Some adjustment was made by the body, approximately 50 per cent—the intake in the usual meals was reduced by 500 calories. The students gained weight. This practical experiment indicates that there is a regulatory mechanism in man that *helps* to maintain energy balance, but it appears not to operate perfectly in all persons (*12*).

At one time it was thought that the contractions characteristic of an empty stomach brought about the desire to eat. Doubt was cast on this, however, when in experimental animals the desire for food continued after the contractions of the stomach were stopped by severing the nerve connections, or by actual removal of the stomach.

Psychosomatic influences. It is believed that some persons eat excessively to compensate for distraught feelings and pent-up emotions. Idleness and boredom tend to lead to nibbling; taking a snack seems to help break the monotony.

A more fundamental emotional involvement is described by Bruch (*3*). She believes that the weight the body stubbornly holds is the "preferred" weight for that individual. It may not be the weight the person professes to desire or the weight the doctor may have recommended. It is the weight, however, that the body "in its mysterious self-regulatory capacity, *prefers* as its pattern of adaptation." Bruch points out that there is need to differentiate between increase in weight that is a normal variation in body build and that which is a fundamental factor in the adaptation of the individual, occasioned by a variety of underlying factors.

Lowered energy need with age. It is characteristic of persons past middle age to tend to gain weight. The explanation lies in the diminishing energy need with advancing age. The basal metabolic rate is lower, and in addition there is usually a greater disinclination to exercise than in the younger years. The decreased energy need gradually creeps up on people. They fail to adjust their caloric in-

downward accordingly and as a consequence begin to accumu- fatty tissue to a greater than desirable degree.

nsufficient exercise. Among the general causative factors contrib- g to overweight is failure to engage in sufficient exercise (*1*). act, Mayer and Stare (*25*) of Harvard have called inactivity "the st important factor explaining the frequency of 'creeping' over- ght in modern Western societies." We enjoy the use of many r-saving devices which, we are reluctant to admit, contribute to failure to exercise. It is a genuine help to sedentary persons who e a tendency to gain weight to plan for themselves a regular edule of physical exercise properly strenuous for their age.

Food and friendship. Serving food is a friendly gesture and as such en results in the consumption of more food than is desirable for ight watchers. Eating together and giving gifts of food are in- ral parts of our social life. No one wishes to change these cordial stoms, but it does mean that for persons wishing to control their ight, adjustment for the added energy must be made in other als of the day.

Habit. Habit is responsible for overweight in many people. The actice of following certain meal patterns and selecting certain foods continued even though the energy need may have been reduced. r example, if 60 extra Calories of energy are consumed each day (an tra slice of bread, or one small apple, or two Brazil nuts, or a ecified amount of any other food) in a year it would amount to ,900 Cal. which is roughly equivalent to 2433 gm fat (21,900 l. 9 Cal. per gm fat), or about 5 lb continued for ten years, about lb will have been added to the body weight.

lation of obesity to health

Certain ill effects to health are attributed to obesity (*13*). Average ood pressure is found to increase with gain in body weight for ght (*23*). Obesity, it would seem, predisposes susceptibility to betes, for most diabetics are overweight to some degree at the on- of the disease. Information provided by life insurance companies their policy holders indicates that in addition to diabetes, over- ight persons are predisposed also to cirrhosis of the liver, appendi- is, chronic nephritis, gall-bladder disease, and heart disease (Table).

The relationship between the incidence of obesity and heart disease not entirely clear. Whereas life insurance statistics show obesity be a predisposing factor to heart disease, a study of coronary heart

Table 38. Principal Causes of Mortality of Persons 20 to 74 Per Cent Overweight

Causes of death	Per cent actual of expected deaths	
	Males	Females
Diabetes	383	372
Cirrhosis of the liver	249	147
Appendicitis	223	195
Chronic nephritis	191	212
Cerebral hemorrhage	159	162
Gall bladder disease	152	188
All heart disease	142	175

Adapted from Dublin and Marks, *Trans. Assoc. Life Ins. Med. Dir.* **35**: 251, 195

disease among men 46 to 64 years of age living in Minneapolis showe coronary patients to have no greater tendency to obesity than men o the same age of normal health (*18*).

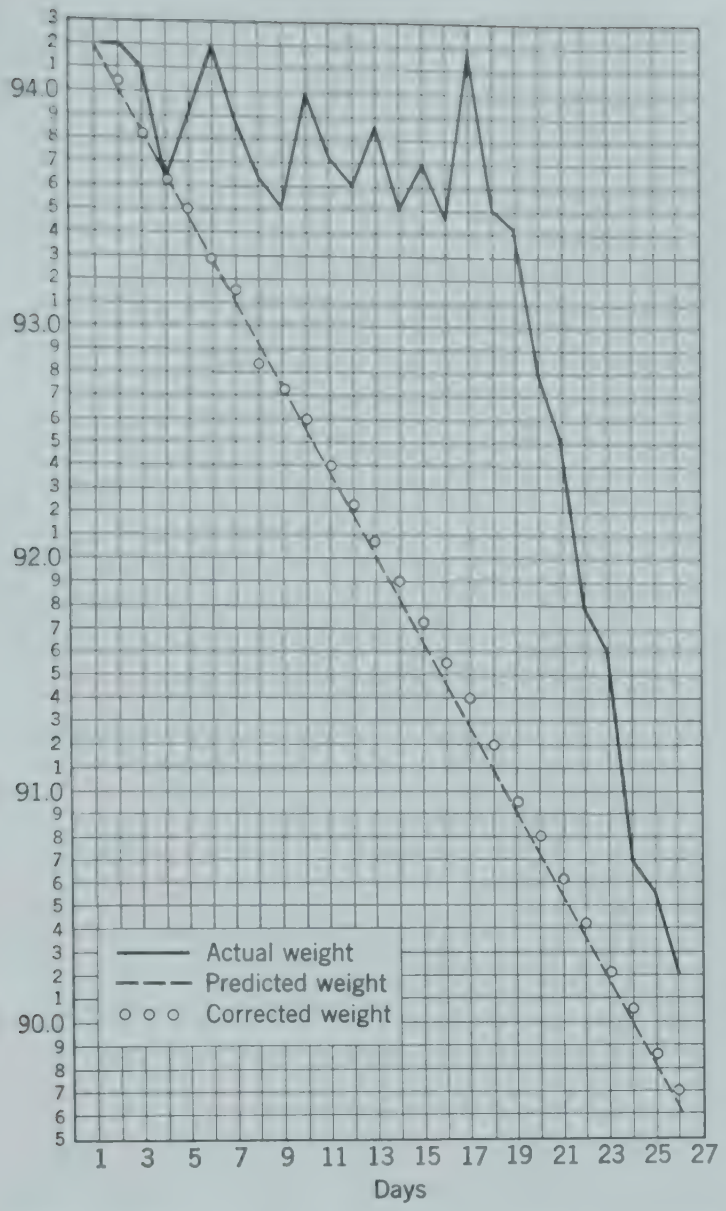
Management of a reducing diet

The time to begin curtailing the caloric intake is when the firs extra pounds are added. Better than reducing is avoiding the nee of doing so.

The diet for weight reduction is restricted in energy value, but wit the protein, mineral, and vitamin content maintained at an adequat level. The shortage of Calories in the diet is made up from the store of body fat. The energy value of the diet should be sufficiently limited to bring about a loss of fat at a rate compatible with health it is generally recommended that the rate not exceed around 2 l per week.

The diet should be acceptable, insofar as possible, to the person wh is reducing, containing foods that are especially enjoyed and offering possibility of making choices among foods. Such a diet plan can the be adhered to with less feeling of deprivation. It is likely that the die pattern, with some liberalization, will need to be followed even afte normal weight has been attained. When there is a tendency to b overweight a watchful eye to the caloric intake is a good investmen in prevention.

The energy level for reduction is peculiar to each individual. I general, however, the level recommended for moderate weight reduc tion ranges between 1000 and 1500 Calories for women, and betwee



. 109. The weight curve of an obese girl. (From Newburgh and Johnston, *ce Exchange of Energy*. Charles C Thomas Company, Springfield, Ill., p. 93, 30.)

00 and 2000 Calories for men. These levels approximate roughly e energy need for basal metabolism per day. If the deficit is ap-oximately 1000 Calories per day, theoretically a loss of approxi-ately 2 lb per week may be expected.

Irregularity in weight loss of an individual who is maintained on a et of the same caloric value day after day may be due in part to fferences in water retention, also the amount of exercise. An un-sually high weight loss, 5 or 7 lb, in the first week or so on a reduc-

ing diet is most likely due to water loss. On the other hand, failu
to lose weight even after faithful adherence to the low-energy diet fo
as long as 2 weeks' time may be due to retention of water in th
tissues. Then there may occur a considerable loss of fluid by way o
the kidneys within a period of a few days, with a loss of weight su
ficiently great to approach that theoretically anticipated in accordanc
with the caloric restriction. Thus water retention may mask for
few days the loss of fat. Those who persist on the restricted diet an
do not surrender with the plea that "it makes no difference when
eat less" are rewarded often by a sudden and sizable reduction i
weight. The same pattern of reduction may then be repeated.
plateau followed by sudden and considerable loss of weight (*28*)
(Fig. 109).

Diet plans that are adaptations of the normal diet are most satis
factory for reduction. In average diets the distribution of energ
among the three foodstuffs, carbohydrate, protein, and fat, in term
of per cent of total Calories is as follows: for the adult, carbohydrat
50 to 60, protein 10, and fat 30 to 40; for the child, carbohydrate 5
protein 15 per cent, and fat 35. In reducing diets these percentage
are changed according to the type of diet fed. The relative propor
tion of energy from carbohydrate, protein, and fat has been varie
in reducing diets in an effort to obtain a palatable food intake tha
allays the feeling of hunger often experienced, and to prevent th
physical exhaustion often felt during reduction.

Diets relatively low in fat have been the usual pattern for reducing
(*2*, *20*). Diets moderate in fat content (approximately 50 per cent o
the total energy), low in carbohydrate (20 to 25 per cent of the tota
Calories), and high in protein (25 to 30 per cent of the total calories
are found to give more satisfactory weight losses in college women
than the diets low in fat (*36*). A feeling of satiety accompanies th
consumption of this diet; there is less hunger between meals. An un
usual sense of well-being is enjoyed by those on the restricted diet

The same dietary plan can be used for weight reduction as for
normal nutrition by omitting the high energy foods, especially those
which supply "Empty calories" (Calories without food nutrients).
A daily food pattern for an adult that provides an adequate intake of
the essential nutrients but is restricted in caloric value follows:

Vegetable 2 servings (⅔ cup) of green or yellow vegetables
1 serving (⅔ cup) of another vegetable
(1 medium potato may be included to take the place of a serving of
cereal or bread)

ruit 1 serving of citrus fruit or other rich source of ascorbic acid
1 serving ($1\frac{1}{2}$–$2\frac{2}{3}$ cup) of another fruit
leat 3 oz lean meat, fish, or poultry
1 other source of good protein, may be another serving of meat or a milk product or legumes
gg 1 each day (or 3–5 per week) as such or in other foods
Ilk 1 pt of milk daily as such or in other foods. The milk may be skim milk
ereal 2 servings of whole-grain or enriched cereal; this may be 2 slices bread (no cereal) or cereal may be substituted for 1 slice of bread
at 2 tbsp., may be butter, enriched margarine or other fat.

Using this dietary pattern as a guide, the following menu has been ned providing almost 1200 Calories, with approximately 50 per t coming from fat, 35 per cent from carbohydrate, and 15 per t from protein. In actual practice, foods other than those listed in diet plan that are of comparable energy value may be selected ording to the taste of the individual. Vegetables and fruits rel- ely low in caloric value (Table 39) may be used freely.

	Calories	Prot., gm	Fat, gm	CHO, gm
AKFAST				
Orange juice ($\frac{1}{2}$ glass)	54	1	tr	14
Egg. (1)	77	6	6	tr
Toast, ww (1 slice) plus 1 tsp. butter	88	2	4	11
Milk, skim (1 glass)	87	9	tr	13
(Coffee, if desired, no cream or sugar)	0	0	0	0
	306	18	10	38
NCH				
Broiled meat patty (2 oz)	200	13	17	0
Green beans ($\frac{2}{3}$ cup) with 1 tsp. butter	51	1	4	4
Celery sticks (1 cup)	18	1	tr	4
Apricot (4 medium halves + 2 tbsp. sirup) without added sugar	100	1	tr	26
	369	16	21	34
NNER				
Pot roast of beef (3 oz)	265	22	19	0
Carrots ($\frac{2}{3}$ cup) with 1 tsp. butter	62	1	4	6
Head lettuce ($\frac{1}{5}$ head) with lemon juice	7	1	tr	1
Bread ww (1 slice)	55	2	1	11
Milk, skim (1 glass)	87	9	tr	13
Pineapple, fresh ($\frac{2}{3}$ cup)	50	tr	tr	13
	526	35	24	44

To be omitted from a reducing diet are the extras, such as the hipped cream on the baked apple, the dressing on the salad, and the

jelly on the bread. These adjuncts quickly increase the total calo intake and contribute little to the nutrient content of the diet. Table 40 some of the foods to be avoided are listed.

Is there a fast and easy way to reduce? Having put on weig over a long period, a long period should be required to take it o The understandable eagerness of the overweight person to comple the reducing project in a hurry, has prompted the concoction of "f diets" and "proprietary mixtures" claimed to hasten the process. Su

Table 39.

VEGETABLES SUPPLYING APPROXIMATELY 5 TO 25 CALORIES PER SERVING (⅔ CUP		
Asparagus	Cucumber	Parsley
Beans, green	Endive	Pepper
Cabbage	Escarole	Radishes
Cauliflower	Lettuce	Sauerkraut
Celery	Mustard greens	Squash, summ
VEGETABLES SUPPLYING APPROXIMATELY 25 TO 50 CALORIES PER SERVING (⅔ CUP		
Beets	Kale	
Broccoli	Rutabaga	
Brussels sprouts	Spinach	
Carrots	Tomatoe	
VEGETABLES SUPPLYING OVER 50 CALORIES PER SERVING (⅔ CUP)		
Beans, Lima	Peas, green	
Corn	Potatoes, white	
Onions	Potatoes, sweet	
Parsnips	Squash, winter	
FRUITS SUPPLYING APPROXIMATELY 100 CALORIES		
Apple, 1 medium	Orange juice, 1 cup	
Apricots, 4 med. halves (syrup packed)	Orange, 1 large	
Banana, 1 medium	Peach, raw, 2 medium	
Cantaloupe, 1 melon (5 in. diameter)	Peach, canned in syrup, 2 lg. halves	
Dates, 4	Pear, 1 raw	
Grapefruit, ½ large (5 in. diameter)	Pineapple, 1 cup raw, 2 sm. slices	
Grapefruit juice, 1 cup	canned	
Grapes, 1 cup	Raisins, ¼ cup	

Table 40. Foods to Avoid in Reducing Diets

Candy	Jelly, jams, and similar sweets
Cream	Mayonnaise
Fatty meat	Nuts
French dressing	Pies, cakes, and rich desserts
Gravy	Rich sauces

gular means may jeopardize health. A drastic and unusual reduc- diet such as the "banana and skim milk" diet, or the diet that sists of a "special tablet," or just eggs for some of the days of the k and the usual diet the remainder, are generally low not only in rgy content as they should be, but also in one or more of the fients, all of which should be adequate in a reducing diet. Such s are not acceptable for a long time program, either from the ritional standpoint or palatability. The proprietary mixtures, pills, tablets, some of which depress the appetite, should be taken y on the recommendation of a physician and with his continuous ervision.

A practice commonly followed by persons who wish to reduce is skip a meal, particularly breakfast. We now have research to w that this is not a good plan. Omitting breakfast lowers an jividual's efficiency in the late morning hours. Furthermore, omis- n of a meal usually results in a less adequate total nutrient intake. e breakfast studies are reviewed more completely in Chapter 23.

ying reduced

Taking off weight is only the first step; keeping it off is the second oblem and often a continuing one (*17*). Additional Calories should returned to the diet gradually and only to the extent that there is t an increase in weight. Restriction in food intake is apt to leave e person with a feeling of deprivation; eating is normally an enjoy- e experience. Satisfaction in achieving the desired loss in weight, wever, is compensation for those who are seriously intent on that al.

e problem of undernutrition

Causes of undernutrition. Undernutrition may result from a short- e of food, from an inadequacy of certain nutrients, or from an ill- nctioning body that fails to utilize the nutriment supplied to it iciently.

Insufficient food is a world problem (*31*, *33*). There is not enough od in some countries today to allay hunger or to prevent wide- read undernutrition. In Fig. 110 the energy and animal protein pply in areas of the world as estimated by FAO are given; the ailable food in many countries is so meager that millions are hungry. ilure to grow because of lack of food (Fig. 111) and the develop- nt of deficiency diseases like kwashiorkor from a lack of protein d other essential nutrients plague the children of these countries.

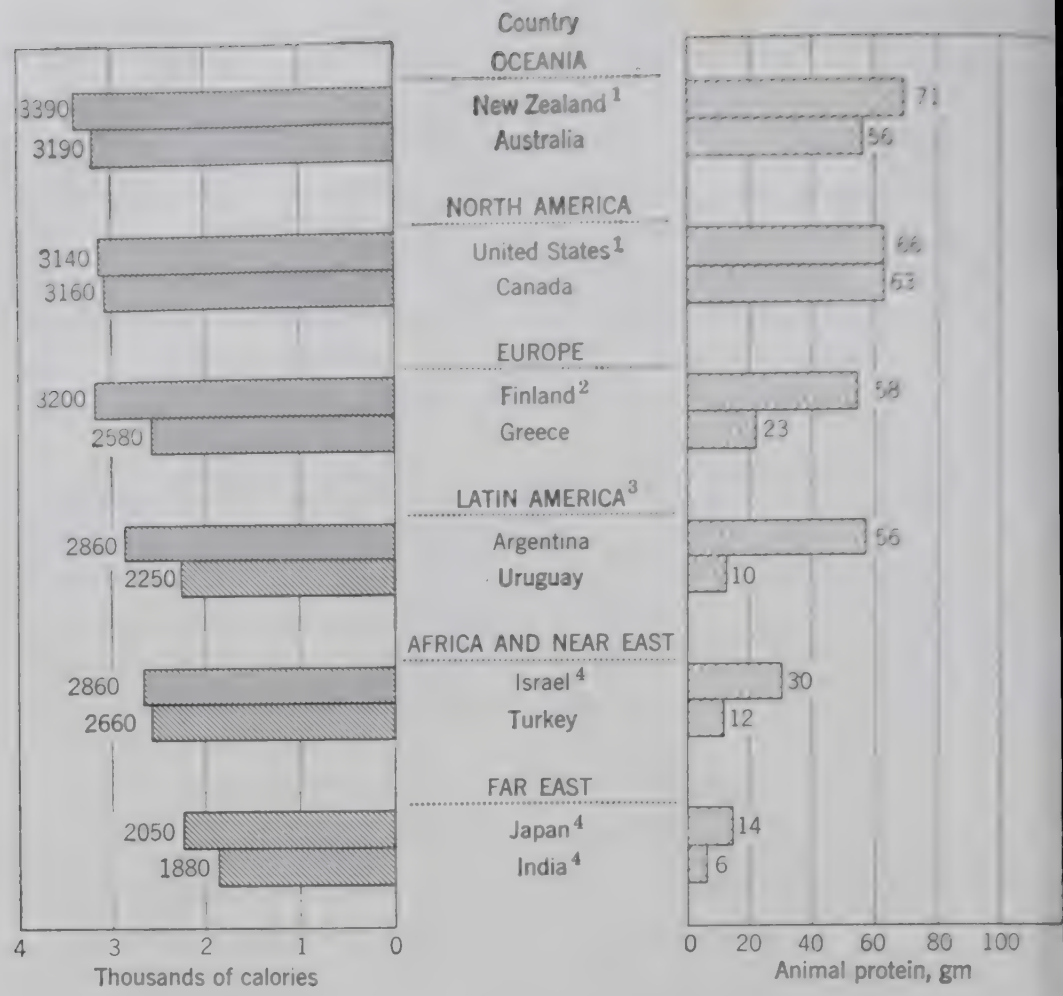


Fig. 110. Estimated energy and animal protein content of national average food supplies per person per day for the period 1954–55 to 1956–57. The selection of the countries in each region was based upon the protein content of food supplies—the highest and lowest are included. (From *Yearbook of Food and Agr. Statistics*, U.N. Food and Agr. Org., Rome, Italy, p. 235, 1957.)

[1] Calendar years instead of split years.

[2] 1954–55 to 1955–56.

[3] Calendar year 1955.

[4] 1954–55.

Poor digestion often characterizes undernutrition and further diminishes the nutriment available to the body.

The underweight person. Undernutrition in the midst of a shortage of food is to be expected; its occurrence in the midst of plenty is an existing paradox. Some individuals, both children and adults, who are underweight fail to gain weight despite an adequate supply of available food. Status of health and habits of life influence the ability of persons to gain weight. Improvement in general health is, as a rule,

ompanied by an increase in appetite, and a consequent gain in ght. Living at a rapid pace in an atmosphere of tenseness with le time for relaxation may lead to poor eating habits, faulty diges- e function, and, as a result, underweight. Slowing the tempo of ng, relaxing for a period before meals, aids in better utilization the food eaten.

The diet for gaining weight should have a Calorie content in excess body needs; protein, minerals, and vitamins should be supplied amounts equal to or above the normal levels. If there is appetite ure foods high in concentrated carbohydrates and fats should be oided because of their satiety value. Eating a little more at each al than is desired, and making a habit of eating between-meal snacks



g. 111. Two boys of the same age. One worked in a coal mine eating such od as is normally available. The other spent four well-nourished years at a arding school. (Courtesy Food and Agriculture Organization of the United ations, Rome, 1957, from *Millions Still go Hungry*.)

that are low in satiety value, such as graham crackers or fruit, as means of adding to the total energy intake.

The effects of undernutrition. With children, and the young of other species as well, an inadequate food intake limits growth. Heredity endows each individual with an impulse to grow, the capacity to do so is controlled by the environment. A most important factor in the environment is nutrition. In experimental animals, deprived of sufficient energy intake to take care of their daily needs, the stores of fat are first called upon to supply the needed energy, followed by protein from muscle tissue. There is little loss of weight in the brain, bone, and kidney tissues during inanition; a greater loss occurs in the heart, liver, pancreas, and the organs of the alimentary tract.

The normal resiliency of the body to stresses is reduced in the severely underfed person. He is more susceptible to cold, manifesting a subnormal body temperature. There is a tendency to subnormal blood pressure, and to edema. Disease is more prevalent and recovery from illness, surgery, and injury more delayed than in the normal person (*29*). Tuberculosis and rheumatic fever are both linked with inadequate food intake as a causative factor.

Normal tissue function is dependent on adequate nutrition. The gastrointestinal tract is particularly susceptible to the effects of an inadequate diet. Limited and monotonous food supply may result in loss of appetite, gastrointestinal motility may be disturbed, and diarrhea, one of the most serious complications of severe deprivation, may develop. The liver, too, may suffer damage, particularly by a diet inadequate in protein, becoming more susceptible to injury by toxic agents.

Voluntary physical activity is altered by the degree of undernutrition. Children who are mildly undernourished show an increase in motor restlessness. Marked loss in body weight results in weakness and tiredness. The capacity to do physical work decreases with continued calorie restriction (*34*).

The welfare of individuals and the global problem of relations among nations make the food shortage in parts of the world a matter for concern. The emotions and behavior of people are altered by deprivation of food. Irritability, gloominess, and an uneasy state of mind prevail. During semistarvation or severe food restriction people are intensely preoccupied with thoughts of food. As the shortage progresses, it becomes a matter of each man for himself. Despite the state of unrest, a great apathy rests over semistarved persons (*15*). The effects of undernutrition on individuals vary with the severity of

deprivation and the capacity of the individual to adjust to the sical and mental stress.

daptation to undernutrition. The body possesses great power of ptation to stresses imposed upon it (5, 27). Cannon suggested that term "homeostasis" be used to describe the ingenious mechanisms rating in the body to maintain normal conditions, and to restore physiological processes to the "steady state" when they have been urbed.

he body adjusts to undernutrition remarkably well; evidence for is the survival of deprived persons, even though at a lowered level well-being. Body weight is lowered, the basal metabolism re- ed, and activity restricted with insufficient food. Each of these nges diminishes the energy need. Within limits, the body thus uces its energy needs in accordance with the energy supply ilable to it.

To further illustrate the adjustment capacity of the body as to a ered food intake, we may cite the more efficient use that it makes protein and calcium when the intake is limited. With protein, a or two after the nitrogen intake is decreased, the nitrogen excre- n in the urine begins to decrease. Thus, in a week or so, nitrogen uilibrium at the lower level of intake is established. Adjustment a limited calcium intake requires a much longer time than for pro- n. There is evidence that calcium liberated within the tissues and dy fluids can be reused thus conserving the available supply.

The capacity for nutritional adaptation is explained by Mitchell 7) in this way: "If an animal in equilibrium with its food supply eaning a well-nourished animal) is subjected to nutritional stress, ch as an inadequate (or an excessive) supply of one or more of the ential nutrients, the animal will react in such a way as to minimize, far as possible, or to undo entirely the effects of the nutritional ess."

Rehabilitation following undernutrition. The severely undernour- ed person is found to make good progress toward recovery on a t high in Calories and generous in protein content. Intravenous eding has proved to be less effective than taking food by mouth. eding predigested foods seems to hasten recovery no more than es ordinary foods. It is best for emaciated persons whose stomachs ve shrunk from lack of food to eat small amounts at frequent in- rvals.

Can refeeding completely overcome the ill effects caused by dep- ation of food? We can only answer this question in generalities. he degree of emaciation, individual differences in capacity to with-

stand such a stress, and the duration of the deprivation are fa
that make a difference. In general we may say that recovery can
complete. This conclusion is based chiefly on studies of British
French children whose growth was retarded by wartime restrictio
but who later did attain their expected size. It is likely that ad
do not suffer permanent injury unless the deficit of certain nutrie
has been extreme and prolonged.

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CHAPTER 21

Food fads and fallacies

Fallacious beliefs concerning foods and their usefulness to the bo may influence eating habits in ways that may be harmful to healt Self medication may be encouraged. It is thus a continuous challeng in nutrition not only to disseminate sound information but also to e pose beliefs that are unsound.

We may wonder where erroneous ideas arise that people believ Those who have investigated the matter believe that much of th misinformation originates from facts that are sound and true but a misunderstood or intentionally distorted. In some instances the mi conceptions are of long standing, beliefs that have been handed dow from one generation to the next, sort of "old wives' tales." The are traditional, unquestioned as to verity. In this category we migh place the admonition to "feed a cold and starve a fever." Now w know that this advice is wrong, that the additional heat generate when the temperature is elevated requires more rather than le energy, and consequently more rather than less food.

Some fallacious beliefs are due to superstitions and fears. Whe traced back to their beginnings, circumstances were usually that illne had followed the eating of a certain food or food combinatio Even though the illness was coincidental, the incrimination of th food as the cause persisted. Such a superstition is the fear of com bining seafood and milk in the same meal. There is no basis, c course, for the fear. In fact, many tasty and wholesome dishes a made using the "fearsome" combination.

Misinformation and partial truths find strong proponents amon pseudoscientists whose only interest is their own financial gain. E

gant claims are made for a product they have concocted or for a
ry plan or health scheme they are sponsoring in order that sales
be realized (*1*, *4*, *6*). The purchase of such nostrums and
ns is an economic waste. Even more serious in some cases is
delay incurred in seeking needed medical attention. Because
ie reckless promises of the unscrupulous for the speedy attainment
ealth, beauty, youth, it is understandable how they can recruit
wers more readily in some instances than can the careful truthful
ner and responsible person.

od faddists, for example, have taken advantage of the interest of
public in weight reduction. Plans are proposed for "reducing
out dieting," disregarding the known facts that weight loss can-
be accomplished unless the energy expenditure exceeds the energy
umption.

n the other hand, we have learned that it is wise to stop and con-
accounts of practices that may vary from those generally accepted
ona fide before summarily condemning them. They may hold
ain of truth. That grain may generate research leading to im-
ant discoveries. Centuries ago burnt sponge was recommended
simple goiter; later it was found to contain iodine, the element
ch, if insufficient in the diet, causes the goitrous condition. The
lish fed limes to their sailors suffering with scurvy; later it was
nd that an insufficiency of ascorbic acid was the cause of scurvy
that limes contain that vitamin.

survey made by a committee of the American Dietetic Associa-
(*2*) indicated the following to be among the more commonly
erved dietary misconceptions:

HAT FRUITS, ESPECIALLY CITRUS AND TOMATO, ARE TOO ACID TO BE
DLED BY THE BODY. The acids in fruits are organic acids. With
few exceptions after absorption, they are oxidized to carbon
ide and water, both of which compounds are readily eliminated.
inorganic residue remaining, after oxidation of the organic
ion, is basic in reaction. Fruits are base-forming with the few
ptions of prunes, plums, and cranberries. These contain organic
s, benzoic in prunes and plums, and quinic in cranberries, that the
y cannot oxidize.

HAT GARLIC CURES HIGH BLOOD PRESSURE. There is no evidence to
cate that garlic possesses either remedial or curative properties
elevated blood pressure.

HAT BEETS BUILD BLOOD. Beets are not a good source of the
ients recognized to be essential in blood formation. Protein and
are the chief blood building constituents. Copper also is essential

for the formation of hemoglobin. Vitamins that function in the maintenance of a normal blood picture include folacin and vitamin B_{12}.

THAT FOODS COOKED IN ALUMINUM UTENSILS WILL CAUSE CANCER. There is no basis of truth for such a belief. Foods cooked in aluminum utensils are increased in aluminum content, but little, if any, of the metal is absorbed from the gastrointestinal tract by man or animal (7). The small amount that may be absorbed exerts no ill effect.

THAT THE FOLLOWING COMBINATIONS OF FOODS ARE POISONOUS: MEAT AND ORANGE JUICE OR OTHER CITRUS FRUIT; MILK AND FISH. The belief is entirely erroneous. Such food combinations are eaten daily by many with no ill effects.

THAT RAW CUCUMBERS WITHOUT SALT ARE POISONOUS. There is no evidence to support this belief.

THAT A GOOD WAY TO DIET IS TO SKIP BREAKFAST. Omission of breakfast results in lowered physical efficiency. Omitting some food from each of the regular mealtimes is a better plan than skipping some meals. (For discussion of overweight and for reports on studies on the effect of omitting breakfast, see Chapters 20 and 23 respectively.)

THAT HONEY IS NOT FATTENING. No particular food is fattening. Calories consumed in excess of need are deposited as fat. A cup of strained honey (338 gm) is higher in caloric value than a cup of sugar (200 gm), 992 and 770 Calories, respectively.

THAT MEAT GIVES YOU STRENGTH. Meat does have a high satiety value. The extractives give a flavor that is enjoyed, and the protein is effective in delaying the onset of hunger sensations.

THAT FRUIT JUICES DO NOT CONTRIBUTE CALORIES TO THE DIET. Fruit juices do contribute Calories to the diet as follows per cup: lime and lemon, 59; orange, 108; pineapple, 121; and prune, 170.

THAT TOAST HAS FEWER CALORIES THAN BREAD. The caloric value of bread is unchanged by toasting. Water is lost in the process and part of the starch is dextrinized, neither of which changes the energy value of the bread.

THAT VEGETABLE FATS AND OILS CAN BE USED IN ANY QUANTITY AND ARE NOT FATTENING. Vegetable fats and oils are high in caloric value and are comparable to animal fats.

THAT ADULTS NEED NO MILK. Without milk or a milk product in the diet, it is difficult to supply the recommended calcium allowance of adults. In addition, dairy products provide in significant amounts protein of high quality, phosphorus, vitamin A, and riboflavin.

THAT SKIM MILK HAS LITTLE NUTRITIVE VALUE. Skim milk is whole

with the butterfat removed. It remains a superior food, even ugh low in fat and vitamin A content.

HAT PORK LIVER IS LESS NUTRITIOUS THAN BEEF OR CALVES LIVER. composition of the three meats is similar in energy value and tein content. Pork liver is higher in iron and thiamine content lower in vitamin A as shown below:

	100 Gram Edible Portion Uncooked			
	Iron, mg	Vitamin A, I.U.	Thiamine, mg	Riboflavin, mg
liver	6.6	43,900	0.26	3.33
es liver	10.6	22,500	0.21	3.12
liver	18.0	14,200	0.40	2.98

rom *Composition of Foods—Raw, Processed, Prepared.* U.S. Department of iculture, Agriculture Handbook 8, 1950.

HAT YOGURT IS AN AID IN RETAINING YOUTH AND BEAUTY. There is evidence to indicate that yogurt or other fermented milks are nder foods. Yogurt is whole milk that has been inoculated with microorganism *Lactobacillus bulgaricus.* It is consumed by some ause the flavor is enjoyed. In certain cases it has been recommended to patients as a means of lessening the incidence of the norly occurring putrefactive bacteria in the intestine.

HAT NATURAL FOODS ARE THE ONLY ONES THAT ARE SAFE FOR THE SUMER. The safety of additives to processed foods is guarded r by the Food and Drug Administration; nutrients are added to ne processed foods to enhance the nutritive value.

HAT WHITE-SHELLED EGGS ARE MORE NUTRITIOUS THAN BROWN. e nutritive value of an egg is not related to the color of the shell; t is determined by the breed of the hen.

HAT LARGE AMOUNTS OF GELATIN DISSOLVED IN WATER AND TAKEN AS OOD SUPPLEMENT WILL STRENGTHEN FINGERNAILS. Fingernail formaapparently is influenced by a number of factors including state nutrition, endocrine state, disease, and environment. Gelatin is a e protein. Whether protein of itself, in any form, will improve gernail condition is questionable.

HAT THE NUTRITIVE VALUE OF FOODS RAISED ON "DEPLETED" SOIL IS R. An impoverished soil diminishes the quantity of the crop duced rather than the quality. Some slight variations in the ritive value of crops can be related to soil fertility. The variety wheat, for example, influences the nutritive value more than the tility of the soil.

THAT WATER IS FATTENING. Water has no caloric value and therefore cannot be converted to body fat.

Protection of the Consumer

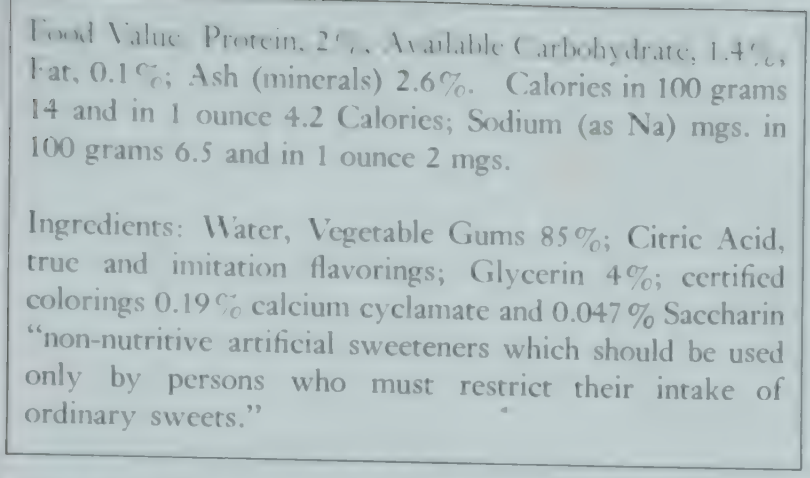
We are fortunate in this country to enjoy certain assurances by law that our food supply is wholesome. Also we may feel confident when making a purchase that the product conforms to the label description. Some of our protection is through federal laws, some by state laws, and some through local regulations. The federal regulations cover products that pass through interstate commerce, the state laws are effective within the state, and local regulations such as county and city apply to those circumscribed areas.

Important among the federal regulations as prescribed by the Food Drug and Cosmetic Act of 1934 is that of accurate labeling of products. Foods bearing labels that are false or misleading are prohibited shipment from one state to another, or importation from another country. The federal law in addition imposes certain specific requirements for the labels of foods intended for special dietary use in order to inform the purchaser of the value of the food for such uses. It is required that the vitamin and mineral content and other

	Approximate Analysis %
Carbohydrate	44.9
Protein (N × 6.25)	35.0
Moisture	7.0
Minerals (ash)	7.3
Calcium	0.90
Phosphorus	0.90
Iron	0.30
Copper	0.001
Fat	4.0
Crude fiber	1.8
Calories per oz	105
Tablespoonfuls per oz	12

Each ounce contains not less than 0.3 mg. thiamine, and 0.1 mg. riboflavin and supplies the above percentages of the minimum daily requirements of nutrients.

Fig. 112. Label from a special cereal preparation for babies. (Courtesy Pablum Products, Division of Mead Johnson and Company, Evansville, Indiana.)


Food Value: Protein, 2%, Available Carbohydrate, 1.4%, Fat, 0.1%; Ash (minerals) 2.6%. Calories in 100 grams 14 and in 1 ounce 4.2 Calories; Sodium (as Na) mgs. in 100 grams 6.5 and in 1 ounce 2 mgs.

Ingredients: Water, Vegetable Gums 85%; Citric Acid, true and imitation flavorings; Glycerin 4%; certified colorings 0.19% calcium cyclamate and 0.047% Saccharin "non-nutritive artificial sweeteners which should be used only by persons who must restrict their intake of ordinary sweets."

113. Label from package of candies for person on diets limited in sugar tent. (Courtesy Chicago Dietetic Supply House, Inc. Chicago.)

tary properties be declared on the label. Fig. 112 is a copy of a el from a cereal preparation for babies. The federal law also kes a special requirement that foods intended for use in diets for dietary management of disease or the control of body weight ry label statements of the percentage by weight of the protein, and available carbohydrate content, and of the caloric value of a cified quantity of the food (*4*). Figure 113 is the label from a kage of candies prepared for use by persons on special diets ited in sugar content and persons on low caloric diets.

The regulations of the state laws vary from state to state. Most them cover mislabeling of products and provide for certain sanitary ulations of products manufactured and put on the market within state. Local laws apply for the most part to control of the lity and sanitation of milk and milk products on the market and the sanitary condition of local eating establishments.

The Federal Trade Commission is another agency that assists in tecting the consumer through the control of false and misleading rtising. The Commission can take action against claims that w a tendency to mislead or could be construed as deluding the blic through advertising by way of radio, television, public lectures, phlets, books, newspapers, form letters, and other types of written mmunication. The Commission can act, however, only if the false misleading matter can be classified as commodity advertising (*5*). The protection afforded the consumer by governmental agencies s not relieve the individuals of their responsibility in attempting discern between fact and fiction. The authenticity of claims made

and beliefs followed can be ascertained only by seeking reliable source of information based on research findings. The frailty of human nature in accepting proffered nostrums without investigation encourages the spread of fallacies.

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HAPTER 22



Diet and dental health

Dental caries is the most widespread chronic disease affecting people lay. It is an affliction that invades all age groups although at ferent rates. Except for a few individuals, each added year of brings new cavities in the teeth. This happens not only in childod but continues in adulthood as well. Girls tend to have a higher idence of dental decay than boys (*13*), not because of a greater ceptibility to dental caries but most likely because girl's teeth erupt ch earlier. Of course, wide individual variation in the incidence dental caries exists at all ages.

A circumstance that might give a clue to the cause of dental caries hat ancient man, in general had relatively little dental decay. This perior condition of the teeth of primitive man was discovered m studies of unearthed teeth. Primitive people living today in ious parts of the world have relatively little tooth decay as did their ient counterparts. However, when civilization reaches them, sufently to materially influence their customs and food habits an inase in the incidence of dental caries invariably follows. Present day mitives, like the Eskimos, have few carious lesions until they have preciable contact with traders or live in the vicinity of trading sts. The Samoans enjoyed a relatively low incidence of tooth cay until navy personnel were located on the island, and the Indians Ecuador had little dental decay until a missionary settlement was blished there (*15, 16, 17, 19*). Dental decay is indeed a greater iction of civilized man than for those living under primitive circumnces.

Structure and Development of the Tooth

It is paradoxical that teeth, which are seemingly so carefully constructed for permanency by having the hardest tissue in the body for an outside covering, should be so susceptible to injury, that is the formation of caries. As shown in Fig. 114, *enamel* covers the entire exposed portion of the tooth, or *crown*. *Cementum*, covers the root the portion embedded in the gum. In the center of the tooth is the *pulp*, a soft connective tissue containing the blood vessels and nerves for nourishment and enervation. Surrounding the pulp is *dentin* which forms the largest portion of the tooth.

Tooth formation begins before birth. Calcification of the deciduous (baby) teeth is in process as early as the fourth to sixth prenatal month. At birth all of the deciduous teeth (twenty in number) are in an advanced stage of development and calcification and the four six-year permanent molars have already begun to calcify in the jawbones. By 2½ years of age, the deciduous teeth of most children are fully erupted.

The first permanent teeth to erupt are the incisors and the six-year molars which appear at about 6 years of age. Often the six-year molars, located sixth in line from the center of the mouth, are not recognized by the lay person as permanent teeth, and as a consequence necessary precautions are not taken to preserve them if they become defective. By the eleventh to thirteenth year the other permanent

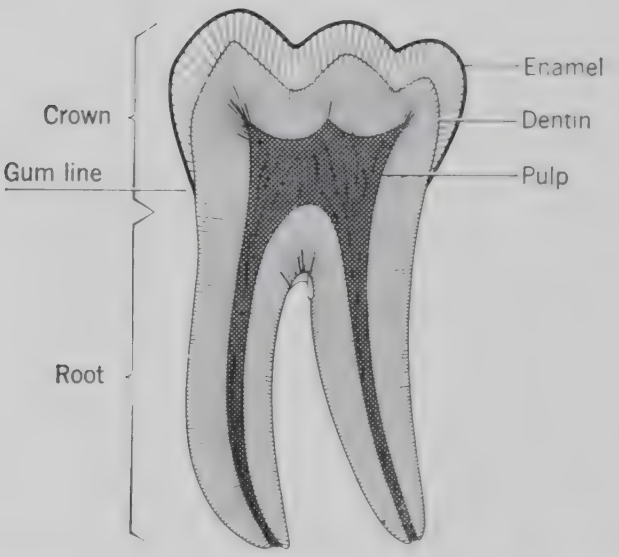


Fig. 114. Cross section of tooth. (Courtesy I. Schour. Adapted from Maximow and Bloom, *Textbook of Histology*, Fourth Edition, p. 381, W. B. Saunders Co., Philadelphia, 1942.)

eth, with the exception of the third molars (wisdom teeth) have upted. The wisdom teeth usually appear between the seventeenth d twenty-first year, although they may erupt later or may remain nerupted in the jaws or may never develop.

Factors Influencing the Incidence of Dental Caries

A complete explanation of the cause of dental caries has not been tablished, although certain influencing factors are recognized. In neral, these influences fall into two classes, those having to do with e oral environment and external contact of materials in the mouth ith the tooth, and those having a systemic effect through materials rried internally into the tooth through the blood supply. The ter influence is of particular significance in tooth development dur- g which the future caries-resistance of the tooth is largely deter- ined.

e influence of oral environment

Microorganisms in the mouth. Microorganisms of the mouth are be- ved to be causative agents of tooth decay. It is likely that any of e organisms that produce acids in the mouth may favor the de- lopment of cavities (*6*). The acidic products formed are found to calcify enamel *in vitro* studies in proportion to their acidity. Al- ough considerable evidence has been produced in support of the idogenic theory, no final appraisal of the mode of the bacterial rticipation in dental caries has been nor can be made at present. roteolysis or chelation, independently or simultaneously with acid calcification may be involved.

There is further evidence that bacteria are involved in caries pro- uction from studies with animals raised with the necessary pre- utions to be bacteria-free throughout long experimental periods. uch animals are free from dental caries, whereas animals with a ormal exposure to bacteria are afflicted with tooth decay. In the periments, rats that were of a strain known to be susceptible to ntal caries were used; a caries-producing ration was fed. In these ontrolled experiments, freedom from bacterial infection was the nly difference between the rats that did not develop caries and ose that did (*14*).

Carbohydrate in the diet. There is substantial evidence that carbo- drate in the diet is associated with the development of dental caries *8*). When no carbohydrate was fed to experimental animals, eedom from caries was possible, with its inclusion caries developed.

This experimental study is most contributive, pointing directly to carbohydrate as a factor in caries production. It would not be possible or practical, however, to provide or afford such a diet, for humans as a routine measure.

The form in which the carbohydrate is fed makes a difference in the extent to which it has a harmful effect on the tooth. Sucrose fed in solution causes less tendency for caries to develop, but when fed in granular form the incidence of dental decay is notably increased. This observation and others indicate that sugars fed in forms that remain in the mouth longest are the most deleterious to the teeth, and that frequency of introducing sugar into the mouth is more related to caries formation than is the total quantity of sugar consumed. Further confirming evidence is afforded in the extensive study made in a mental institution in Sweden over a 9-year period. Sucrose was fed to participants in different forms; to some it was given in solution, to others in bread, chocolate, caramels, and toffee. During the supplementation period the greatest increase in new lesions occurred in the individuals who were consuming the toffee, a sticky kind of candy (*9*).

Influence of saliva. Normal exposure of the tooth to saliva is a deterrent to caries development. This observation was clearly demonstrated in studies with animals from whom the salivary glands were removed. Without saliva, the incidence of dental caries increased markedly in frequency and severity (*3*).

Oral hygiene. Brushing the teeth thoroughly within 10 minutes after each ingestion of food, or if that was not possible, rinsing the mouth, was found to effect a reduction in the incidence of dental caries in a study with college students. The observations covered a period of 2 years with 429 individuals in the experimental group who either brushed their teeth or rinsed their mouths after eating, and 276 persons in the control group who followed their usual habits of mouth hygiene. The control group at the end of 2 years had developed an average of 3.87 new carious surfaces, detected through clinical and radiographic examinations; the experimental group had developed only 2.02 carious surfaces (*8*).

Influence of systemic nutriture

The adequacy of the nutrients supplied the tooth during the formative period influences its resistance to decay. Research studies amply substantiate the beneficial effects of an adequate diet in building a tooth. In the study of the incidence of caries among preschool children at the Forsyth Dental Infirmary in Boston, the diet of the mothers during pregnancy, as well as the diet of the child were found

have an influence. The mothers of children who had a low-caries idence had drunk more milk during pregnancy than had the mothers children in the high-caries group. In addition, more of the low-ies children had had supplements of vitamin D either throughout or during the winter months, and were found to be consuming tter diets at the time of the study than the high-caries group (2). still another experimental study, tooth decay was reduced in chil-en living in certain institutions in New York by supplementation of ir diet with sufficient foods to make the diet completely adequate 2).

Influence of specific dietary nutrients—vitamin D. Vitamin D in the ts of children is found to favor a reduction in dental caries. The st extensive observations are those reported by the Committee on e Investigation of Dental Disease in England (*10*). Children 5 to years old were studied over a period of 3 years in 3 institutions for ildren in Birmingham. Supplements of cod liver oil and vitamin as irradiated ergosterol in olive oil, reduced the incidence of tooth cay.

Calcium and phosphorus. Good retentions of calcium and phos-orus were found to be associated with freedom from dental decay children (*4*). In a study of 98 Iowa children those with no dental ries retained an average of 17 mg of calcium and 15 mg of phos-orus per kg of body weight each day; those with dental caries, the other hand, retained only 10 mg and 9 mg respectively. The fference in retention of the minerals between the non-carious and rious group was sufficiently great to be statistically significant.

Ascorbic acid. It has long been established that ascorbic acid is sential for the development of dental tissues. In scurvy, changes are served in the pulp and the odontoblasts (tooth-forming cells) of e tooth. Caries susceptibility, however, is not known to be in-uenced by the level of ascorbic acid in the diet.

ate of health

Good nutrition, freedom from emotional tenseness, and compliance ith good health habits, are believed to favor a reduction in tooth cay "as a corollary of other evidences of betterment of well-being").

The Influence of Tooth Structure on Resistance to Caries

Teeth that are well formed and calcified seem to have a higher sistance to decay than do teeth that are poorly formed. Mellanby) found in her microscopic examination of 1500 sectioned de-

ciduous teeth of English children, that 78 per cent of those with well calcified enamel and dentin were free from caries, whereas only 4 per cent of the poorly developed teeth (hypoplastic) were caries-free. The gross structure of the teeth also bore a relationship to the caries incidence; the better the structure, the lower the incidence of dental caries (*1*). Although structure is a contributing factor, we must recall that there are perfectly formed teeth that decay, and imperfectly formed ones that do not. It should be noted that perfectly formed teeth in man are a great rarity.

Fluorine and Dental Caries

The role of fluorine in the prevention and control of dental caries is discussed in Chapter 11. The favorable effect of fluorine holds promise that the incidence of dental caries may be reduced when children are afforded the benefit of its use. However at present the benefits are largely limited to those living in areas where there are communal water supplies.

Diet and Health of Periodontal Tissues

The periodontium (periodontal tissues) which includes the bone, connective tissue, and epithelium that hold the teeth in the jaws, is notably susceptible to poor nutrition. Particularly important in the maintenance of these tissues is ascorbic acid. In a study of adult men whose gums had been treated previously for gingivitis, less likelihood of its return existed among those ingesting 75 mg of ascorbic acid daily than those who consumed only 25 mg daily (*11*).

The physical character of the diet may also affect the health of the periodontium. A diet containing foods that require vigorous chewing may be better for the health of the gums than the soft, sticky foods that tend to cling to the teeth, particularly at the gum line, contributing to the development of gingival disease.

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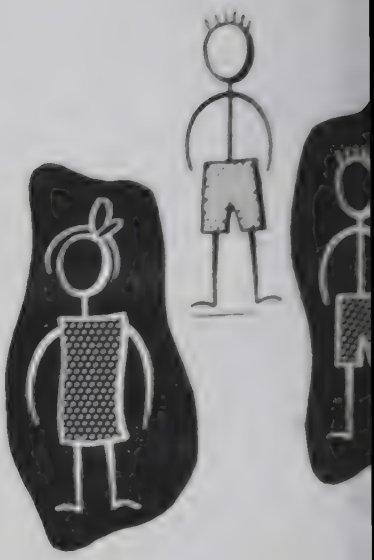
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CHAPTER 23

Nutrition needs of children



Nutritional life really does not begin with birth. It actually begins during the prenatal period and is subjected to influences even earlier. The well-being of the infant is influenced not only by the diet of the mother during pregnancy but also on her status of nutrition prior to that period. Although she may serve to some extent as a factor of safety for the unborn child, the mother who is poorly nourished tends to give her baby a poor start in life nutritionally. The prenatal influence will be discussed more specifically in Chapter 24.

The First Year

At no other time of life is food so important as in the first year. The kind, amount, and sanitation of the food, as well as the manner of feeding, require particular attention, which pays dividends in the form of a healthy, happy baby. The nutrient requirements are high



Fig. 115. Two well-nourished baby girls of one year.

r unit of body weight because of rapid growth; never again after rth is growth so rapid. Furthermore, a baby has had little time build reserves of needed nutrients and must rely on his daily food supply them for the most part.

A well-nourished baby is usually round and chubby in appearance. fter birth he progressively accumulates subcutaneous fat for about 9 onths, after which the amount diminishes. However, by one year may be quite chubby or he may be equally healthy and slender Fig. 115). In the well-nourished infant the muscle tissue feels firm, hich is a good index of his status of nutrition. The pattern of growth ries during the first year; it is most rapid during the first months ter birth. An ounce a day (2 lb a month) may be added to the ody weight during the first 3 months. Then the pace slows to a in of about a pound a month. Increase in length follows a similar ttern; babies increase about 20 per cent in height in the first 3 onths, then they slow down so that by one year the total increase about 50 per cent of the length at birth.

In the following paragraphs research and practical findings related successful feeding of infants will be recounted. This general in-

formation is presented to give an understanding of the fundamentals. So important is this phase of the infant's life that specific directions and supervision of the feeding should come from a physician.

Breast feeding versus artificial feeding

The natural food provided for the human infant is human milk. Even so, either by choice or by necessity, it is not the universal infant food. There has been a trend toward less breast feeding in this country over the last ten years. In 1946 (*2*) a survey of hospitals indicated that as nearly as could be estimated, only 38 per cent of the infants in this country were entirely breast fed even through the newborn period; in 1956 a similar survey showed a reduction to 21 per cent (*9*).

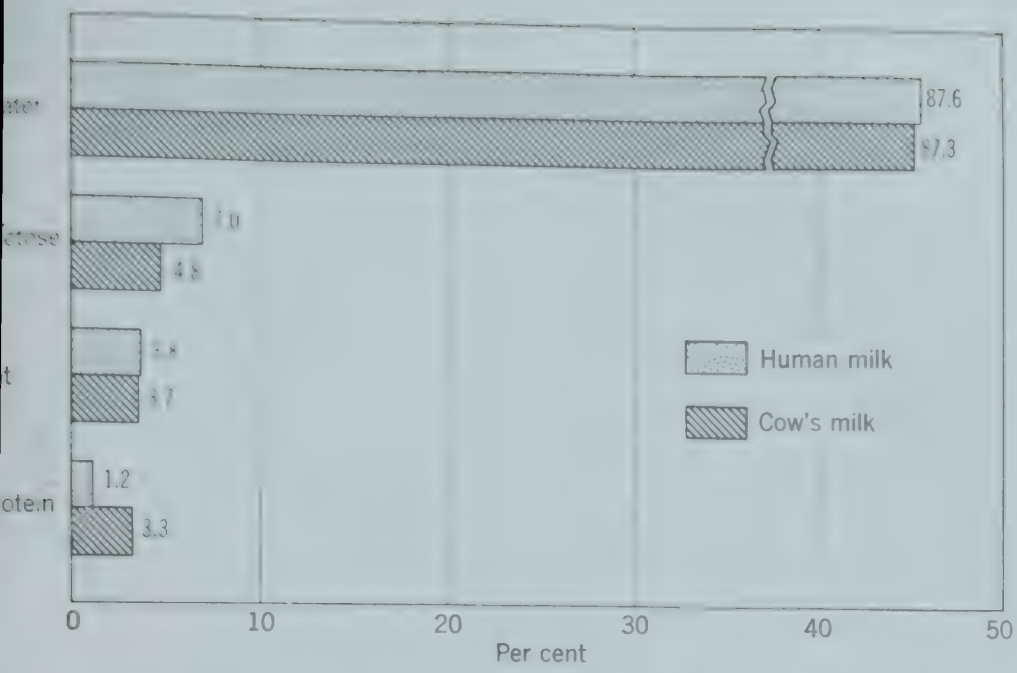
A comparison of the welfare of 263 infants, some of whom were breast fed, and others artificially fed, was made by the Harvard School of Public Health (*17*). There was little difference between the progress of the two groups. During the second 6 months of life the artificially fed infants had a slightly higher incidence of respiratory infections. The mothers of the artificially fed infants were carefully instructed in the method of preparation of the formula and of feeding the baby, which was doubtless a factor in the success.

With improvement in the formulas for artificial feeding there may be no longer any nutritional advantage in prescribing human milk; however, there are advantages still in breast feeding. Important among them are (1) its freedom from bacterial contamination, (2) it requires no elaborate preparation, (3) it improves the parent-child relationship, and (4) it is less likely to be associated with infant eczema and other allergic manifestations (*4*). Economy has been listed as an advantage, but actually the mother requires additional milk and a more abundant diet during lactation.

The choice between breast and artificial feeding is a matter for the mother to decide with her physician. In the judgment of Aldrich and his Committee on Maternal and Child Feeding of the National Research Council, breast feeding has the advantage of preventing or decreasing the severity of many gastrointestinal disturbances, especially in environments where sanitation and health measures are not adequate (*1*).

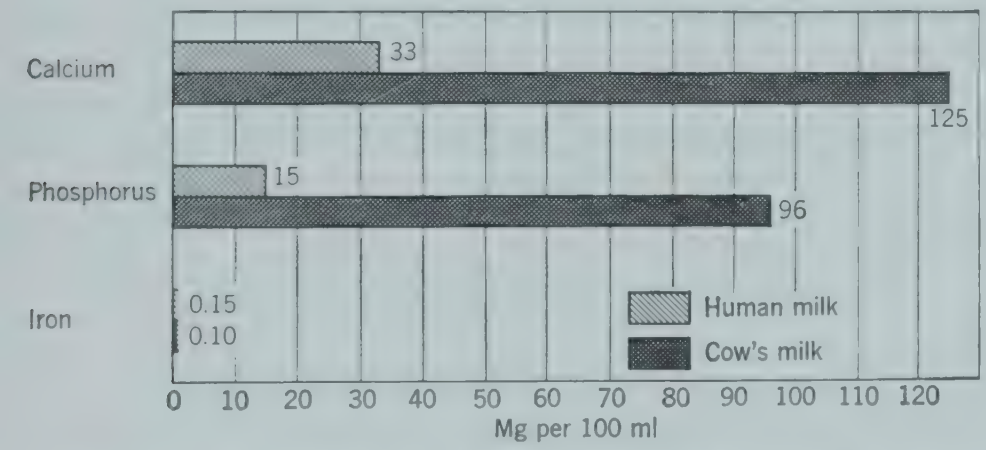
Supplying the needed nutrients

A discussion of supplying the needed nutrients for infants must of necessity focus on milk. The composition varies somewhat with different species. Our chief interest is with human and cows' milk,



116. Composition of human and cow's milk. (Gm of water, lactose, fat, protein in 100 ml milk.) (Adapted from *Composition of Milks*. National Research Council, Bull. 254, Washington, D.C., p. 62, 1953.)

hough goats' milk is sometimes fed to infants. In comparison to ws' milk, human milk contains more lactose, iron, ascorbic acid, and amin A per unit of volume, and less of protein, calcium, phosphorus, oflavin, and thiamine (Figs. 116, 117 and Table 41). It is believed t each milk is adapted for the best nourishment of the young of respective species.



117. Calcium, phosphorus, and iron content of human and cow's milk. dapted from *Composition of Milks*. National Research Council, Bull. 254, ashington, D.C., p. 63, 1953.)

Carbohydrate. Lactose is the carbohydrate in all milks. The quantity in cows' milk is about two-thirds that found in human milk, with the concentration further decreased in the artificial feeding by the addition of water in making the formula. Consequently some form of carbohydrate is usually added in preparing artificial feedings. The kind and amount should be at the discretion of the physician, sucrose and corn syrup are commonly used. The only disadvantage to these sugars is that they taste sweet. Lactose, the sugar that nature has placed in milk for use of the young, is the least sweet tasting of all the common sugars. However, lactose is not used because it is expensive and there is no evidence that it is more satisfactory than other products. Combinations of maltose and dextrins taste less sweet than sugar and syrup and have been used successfully in infant formulas.

Table 41. Vitamin Content of Human and Cows' Milk

(per 100 ml whole milk)

Vitamin	Human	Cow
A, mcg	53	34
Carotenoids, mcg	27	38
D,I.U.	0.42	2.36
Ascorbic acid, mg	4.3	1.6
Niacin, mcg	172	85
Riboflavin, mcg	42.6	157
Thiamine, mcg	16	42

Adapted from *Composition of Milks*, National Research Council, Bull. 254, Washington, D.C., p. 70, 1953.

It should be pointed out that artificial feeding with fresh whole milk and evaporated milk formulas with no added carbohydrate whatsoever has been used by some physicians with success. Some infants thrive on such formulas, others do less well. Mothers seemed to like the omission; the feedings are simpler to prepare.

Protein. The protein content of cows' milk is approximately triple that of human milk. The casein content of each milk is higher than the amount of lactalbumin; however in cows' milk the casein is relatively higher, the lactalbumin lower.

Raw cows' milk tends to form large, firm curds in the stomach of the infant. Dilution of the milk contributes to the formation of softer curds as does heat treatment, acidification, and homogenization.

The quantitative requirement of infants for certain of the essential amino acids has been determined. By using a combination of pure

no acids, in the proportions found in human milk, to supply the ein in the formula, single amino acids were omitted and the re- ise observed. The effect of the lack of the amino acid on growth, ogen retention, and blood plasma protein levels were observed, owed by a quantitative determination of the amount required for mal performance. The amounts needed daily of threonine, phen- anine, lysine, and valine were determined for infants less than 5 nths of age. The findings are summarized in Table 42 (*10, 13, 14,* together with the requirements of the adult male. The investi- ors point out that the diet used was completely synthetic and raise question as to whether a natural diet of the same amino acid make- would give the same results.

Table 42. Approximate Requirement of Amino Acids

(mg per kg)

	Infants	Adults
Threonine	60	7.0
Phenylalanine	90	15.5
Lysine	90 to 105	11.5
Valine	85 to 105	11.5

The amino acid needs of the infant for growth and for the adult maintenance of nitrogen equilibrium are quite different. The mated need of the infant is much greater on the basis of unit of ght, as would be expected (Table 42).

t is of practical interest to know that the requirement of infants for se amino acids is amply supplied through breast feeding or by the vs' milk formulas in common use. Further studies in time will e the complete picture of amino acid needs of babies.

at. The total quantity of fat in human and cows' milk is about the ne, approximately 3.5 to 4.0 gm per 100 ml. The fatty acid ke-up of the fats in the two milks differs however. Cows' milk ntains proportionately more of the saturated fatty acids; human k, on the other hand, is proportionately higher in the content of aturated fatty acids. The occurrence of some of the fatty acids human and cows' milk is given in Table 43. The amount of lino- acid, an unsaturated fatty acid, in human milk is about five times t in cows' milk. Arachidonic acid, also an unsaturated fatty acid, curs in about equal amounts in the two milks.

A new significance has been attached to the unsaturated fatty acids work that Hansen and his co-workers at the University of Texas,

Table 43. Distribution of Some of the Lipid Components in Human and Cows' Milk

	gm/100 gm milk fat mature milk	
	Human	Cow
Total fat	3.8	3.7
Fatty acid distribution		
Saturated fatty acids		
Butyric acid	0.4	3.1
Caproic acid	0.1	1.0
Caprylic acid	0.3	1.2
Capric	1.7	2.6
Unsaturated fatty acids		
Linoleic (octadecadienoic)	8.3	1.6
Arachidonic acid	0.8	1.0

From *The Composition of Milks*. Revised 1953. National Research Coun
Washington, D.C. Bull. 254, p. 65, 1953.

School of Medicine (6) have done. If the fat content of the formu were reduced to less than 1.0 per cent of the total Calories (which exceedingly low, roughly 50 per cent of the energy come from in human milk; in cows' milk formulas 35 to 40 per cent), the sk developed a dry and leathery texture, with fine flecks scaling off t surface. This abnormal skin condition completely disappeared wi the addition of linoleic acid and improved dramatically with the fee ing of arachidonic acid, whereas the addition of a saturated fatty ac palmitic acid, had no effect.

Minerals: calcium and phosphorus. Cows' milk contains over thr times as much calcium, and approximately six times as much pho phorus as human milk. A thriving breast-fed baby receives abo 0.06 gm calcium for each kg of body weight, whereas the artificial fed infant, who receives about 100 ml of cows' milk for each kg, ge 0.12 gm of calcium per kg. Calcium retention is greater in infants f cows' milk because of the higher intake. The retention from huma milk must be adequate, however, since breast-fed babies manifest e cellent growth despite the lower retention.

Iron. Both human and cows' milk contain very little iron. Th infant is born with a store of iron to which the body holds ten ciously, using it throughout infancy. This capacity of the infant retain fetal iron would not have been known had not the use of radi active iron in metabolism studies been possible. One such study w done in this way: women were given transfusions of blood durin

nancy in which the red cells contained radioactive iron, which e it possible to follow the iron on its course, and to locate it in infant.

he hemoglobin level is high at birth (around 22 gm per 100 ml) easing to a minimum (around 10.5 to 11.5 gm per 100 ml) at it 3 months of age, the time that iron-containing foods need to be d if they are not already included in the diet. Providing dietary much earlier is apparently wasted effort for very little, if any, is for hemoglobin formation prior to 3 to 4 months after birth. iron that is used for this function during the first months of life red the body during fetal development (transplacental iron). n at one year 70 per cent of the iron in hemoglobin is trans-ental in origin (*12*). Iron-rich foods used with success at the d to fourth month include egg yolk, green vegetables, meats, and als. If the nutritional status of the mother during pregnancy e poor, and an adequate intake of iron is not provided the infant, n needed, hypochromic anemia is apt to develop. Today it is the t common nutritional deficiency in children in the United States, urring most frequently during the latter half of the first year in nts fed only a milk formula.

e vitamins: vitamin A. Total vitamin A in milk is comprised of ormed vitamin A and the carotinoid pigments. The proportion ne preformed vitamin is greater than that of carotinoids in human ; in cows' milk the two portions are approximately equal.

he Food and Nutrition Board recommend 1500 I.U. of vitamin A for the infant through the first year. This is approximately the unt in one quart of cows' milk of average composition. A quart nilk is more than the infant consumes in a day during his early ths, which makes it understandable that some physicians recom-d a supplement of vitamin A during that period.

iamine. The amount of thiamine in the diet of the mother ng lactation seems to be the major influence on the quantity se-ed into the milk. If the diet of the mother included pork, the mine content of the milk was increased. If the intake of thiamine ained fairly constant from day to day, the milk thiamine re-ned fairly constant, also.

he National Research Council recommendation is 0.4 mg per day the second to the sixth month; and 0.5 from the seventh month ne year. Neither breast feeding, nor the modified-cows'-milk ulas, provide the recommended amounts. The average thiamine ent of human milk is about 0.21 mg per 1000 Calories; the average le milk dilution formula provides not more than 0.24 mg per

1000 Calories, and is most likely less by 20 per cent or more be
of the heat treatment it receives. However, supplements to the
during the first year, the cereals, egg, meat, and vegetables, prov
additional thiamine.

Riboflavin. The riboflavin content of cows' milk varies somew
with the breed of the cow. The most serious cause of loss of
vitamin in market milk is exposure to light; it is stable to heat,
to the processes of evaporation, drying, and homogenization.

The amount of riboflavin in human milk is found to bear a defi
relationship to the riboflavin content of the maternal diet. For
stance, on days when liver was an item in the mother's diet, a hig
concentration of riboflavin followed in the milk.

The recommendation for daily intake of riboflavin for infant
0.5 mg for the second to sixth months, and 0.8 mg from the seve
month to one year. The recommendations are in excess of
amount of the vitamin that would be obtained in either the cow
milk formula or human milk. However, the Food and Nutrit
Board states "the adequacy of human milk in this respect is not qu
tioned," and indicates that although cows' milk contains appro
mately three times as much riboflavin as human milk, "the relat
utilization is not known."

Niacin. Human milk contains about twice as much niacin as d
cows' milk, whereas the reverse is true for tryptophan, the amino a
precursor. Niacin in milk is stable to sunlight, pasteurization, eva
ration, and drying.

The Food and Nutrition Board estimated the intake of niacin o
breast-fed infant weighing 6 kg as follows: assuming an intake o
gm protein per kilogram of body weight the infant would obtain
mg of dietary tryptophan from the milk. If an infant converts try
tophan to niacin comparably to adults (that is 60 mg of tryptoph
may be converted to 1 mg niacin) then the milk will supply 3.3 mg
niacin from tryptophan, and 1.7 mg of niacin itself, a total of 5
daily.

The Recommended Allowance in terms of niacin equivalent, fr
the second to sixth months, is 6 mg and from the seventh month
one year, 7 mg.

Ascorbic acid. The ascorbic acid content of human milk var
with the diet of the mother but generally exceeds that of cows' mi
Commercial processes, including pasteurization, evaporation, and dr
ing are destructive of ascorbic acid, so that little is left by the time
cows'-milk formula reaches the infant. Ascorbic acid is fed to
formula baby as a matter of course today, beginning shortly af

n. For safety, it is usually recommended for the breast fed in
, also. Orange juice is commonly used as the source, although
e young infants do not tolerate it well. As a consequence, there
growing tendency among pediatricians to replace it with ascorbic
preparations.

he amount of ascorbic acid recommended by the Food and Nutri-
Board is 30 mg daily from the second month to one year. That
unt is available in approximately ¼ cup of orange juice.

itamin D. The vitamin D content of both human and cows' milk
es with the content of neither providing enough to assure protec-
against rickets. Despite adding a source of vitamin D to the
ernal diet, an insufficient amount of the vitamin is transmitted to
milk to be curative of rickets in infants. Physicians routinely
ommend a supplemental source of vitamin D for both breast-fed
artifically-fed infants, beginning soon after birth and continuing
oughout the period of growth.

he requirements for vitamin D for infants and children have been
ned by Jeans and Stearns (*8*) as the amounts that, with ample in-
es of calcium and phosphorus, and a diet otherwise adequate, will
re sufficient retention of minerals to permit normal growth and
eralization of the skeleton and teeth. The infant and young child
o are growing rapidly have a proportionately greater need for the
min than the older child. A daily intake of 135 I.U. is sufficient
prevent rickets in infants, but better growth is obtained with 300
400 I.U. daily. The Recommended Allowance is 400 I.U. daily
oughout infancy. Increasing the intake to 600 I.U. is found to
rue no additional benefits to the infant in rate of growth or cal-
m utilization (7, *11*).

here are a number of commercial preparations on the market for
plying vitamin D; some are in combination with vitamin A. The
paration may be in oil or aqueous solution; the latter is preferred
many physicians to avoid the possibility of aspirating oil droplets
o the lungs.

he use of vitamin preparations. It is easy to exceed the recom-
nded level of vitamin intake by the use of vitamin concentrates. A
dy of the vitamin A intake of 64 Denver children showed that after
first 3 months, three-fourths of the children met the Recom-
nded Allowance by diet alone. Then in addition a concentrate
vitamin A was given 64 per cent of the time, which gave a median
ake of 10,000 I.U. of vitamin A from all sources. The Recom-
nded Allowance is only 1500 I.U. for children of that age (Fig.
).

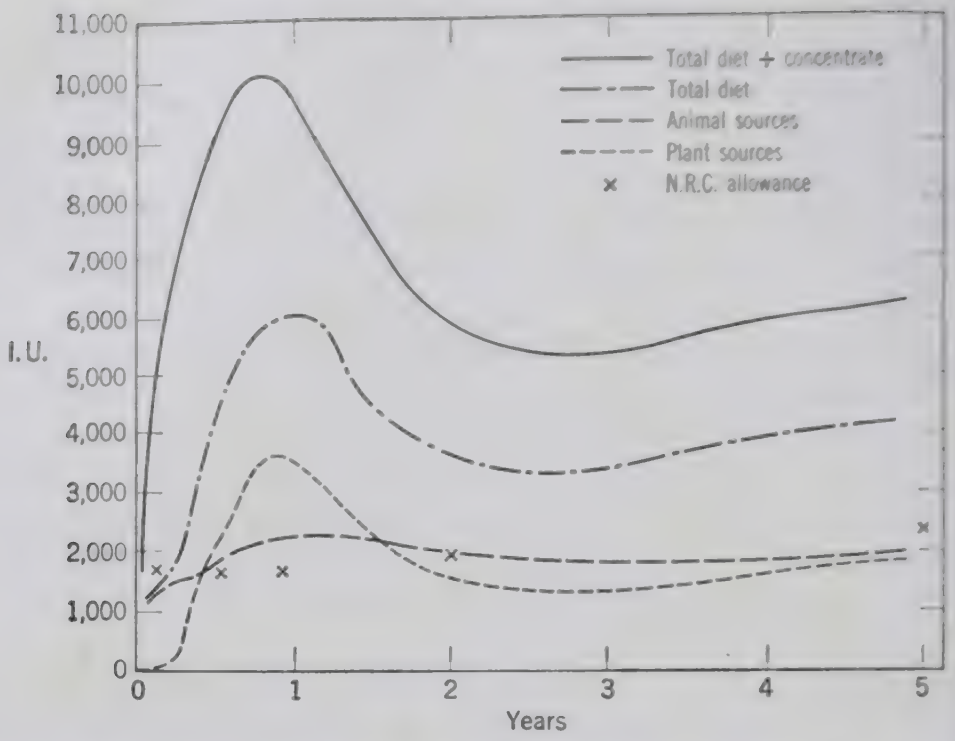


Fig. 118. Median intake of vitamin A from various sources contrasted with Recommended Dietary Allowance in the first 5 years of life. (Courtesy B *J. Nutrition* **60**: 340, 1956.)

The intakes of vitamin D and ascorbic acid of the same group Denver children that were observed for the vitamin A content of t diet, showed the median intake of vitamin D to be 1000 I.U. daily 4 to 6 months; 840 I.U. daily at the end of the first year. Most the ascorbic acid intake was from preparations of the vitamin rath than from food sources during the first 6 to 9 months, after whi the diet was the major source. The median intake of ascorbic ac increased from 20 mg daily at one month to 53 mg at one year (The long-term effects of moderately high intakes of vitamins have n been determined to our knowledge, but warrant attention; we a concerned that growing children have the amount of necessa nutrients for their best health—*neither too little nor too much.*

Adding "solid" foods

Some babies are given solids as early as the first 4 weeks of li others not until 3 months or later. A comparison of the response two groups of infants, one with early feeding of solids, the other wi later, revealed little difference in growth rate, number of illness incidence of digestive disturbances, and food refusals (5). Spock a

enberg (*16*) give us the general recommendations that babies ld be having some variety of solid foods by the time they are 5 months old; in some cases earlier than that; in others, later. The of adding solid foods is an individual matter, influenced by rity of the infant, appetite, digestion, and tendency of the in- toward allergies. There seems to be no physiological need for e foods until the third or fourth month; at that time they are ed particularly to supply iron and thiamine but make valuable ributions to the intake of other nutrients as well.

ereals are commonly added first to supply extra energy, iron, mine and other nutrients. Pureed fruits are tolerated well as a , and are frequently added next. The pureed vegetables then be- e a part of the expanding diet, as do egg yolk and strained meats.

ding the baby

Greater emphasis is now being directed toward early feeding ex- ences of the infant in relation to his emotional development. ring the first months of his life he learns whether or not he can t the people on whom he is dependent. He experiences hunger, with the satisfaction of that need he has a feeling of trust for the son who feeds him. Being hungry is one of his first frustrations, ng fed one of his first satisfactions. The understanding of the damental importance of these first experiences of the infant has lted in a departure from the rigid feeding schedule whereby the nt was fed at regular intervals, whether it meant awakening him m a sound sleep or letting him cry until the appointed hour for the ding arrived. The inflexible schedule has been replaced by the -regulation schedule, in which the baby determines his own feeding edule to a considerable extent. Mothers as a rule learn to know en the cry is a hungry one or for some other need. On occasion rigid permissiveness, that is feeding the baby at each cry is as as too rigid discipline. During the first weeks of life, infants on -regulation schedules tend to choose a feeding interval of less than ours, with the interval lengthening so that by one year of age the eral regimen of three meals a day is satisfactory to them.

The Preschool Years

During the years from 2 to 6, which are commonly designated as preschool years, growth proceeds at a slower rate than during the t year. Within this period the baby leaves behind babyhood and velops into childhood. The gain in weight may be only 4 or 5 lb



Fig. 119. A preschool child of 34 months.

in a year during the preschool period, whereas the infant may gai
that much in a couple of months when he is very young. The pre
school child grows relatively more in height and takes on an appear
ance of being taller and thinner. The round, chubby look of baby
hood is gone; the arms and legs grow longer in proportion to th
trunk; the short neck of infancy grows longer, and the head, whic
at birth accounted for about one-fourth of his total length, grow
more slowly and assumes less of the total stature. The preschoo
child is streamlined in comparison to the chubby infant (Fig. 119).

The well nourished preschool child is sturdily built. He graduall
overcomes his infantile lordosis (sway-back) and uncertain waddle t

me more like the adult in posture and stride. The well, normal is alert and busy exploring his environment, establishing himself individual in it.

he nutrient needs of children is an individual matter influenced by rate of growth, activity, and status of nutrition of the child. ce, the following discussion of food requirements sets forth ral principles as guides to be adapted to each child.

ient needs of children one to six

alories. The National Research Council, with emphasis on individual variation, suggest 1300 Calories daily for the child from 1 , and 1700 Calories for the child from 4 to 6 years of age (Table The best measure of adequacy of energy intake is gain in body ght. That does not mean growth in reference to standard tables that each child is gaining at his own individual rate. Ideal supplets to increase the caloric intake are foods high in nutrient content as milk, fruits, vegetables, and cereals (whole grain or enriched). ds to be avoided are concentrated sweets and foods high in fat.

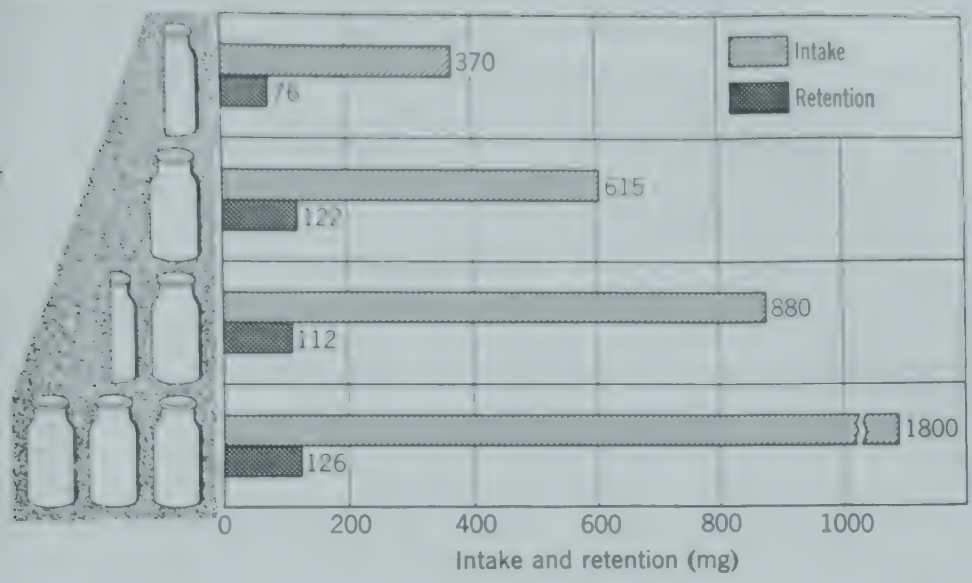
rotein. Protein in the diet of the preschool child is of particular ortance, because these years are marked by notable increase in cular development. His musculature is limited, his activities tless (*6*). The Recommended Allowance for protein in early dhood is around 2½ to 3 gm per kg per day. This allows for ations in growth needs and provides for some storage of protein he body. A norm established for body weight of 2 year olds is kg, with extremes ranging from 10 to 15.5 kg; for 5 year olds 18.4 with extremes ranging from 15 to 24 kg. If the average values for y weight and the allowance of 3 gm of protein per kg are used to an approximation of total protein intake recommended daily, und 37 gm would be the amount prescribed for 2 year olds, and und 55 gm for 5 year old children. With careful planning of the 's meals for the family, the preschool child's needs can be met n the family fare. Foods in the day's diet that can be counted on upply protein are: a glass of milk at each meal (providing approxiely 24 gm in 3 glasses), an egg or meat, or both, supplying 6 to 15 These foods, together with the amount supplied by the reder of the diet provide from 40 to 50 gm of protein daily.

alcium. Preschool children were found in a study of calcium zation to retain as much calcium from a pint of milk as from one one-half pints or one and one-half quarts (Fig. 120). The Food Nutrition Board, however, recommended one gm of calcium y. The justification for the more generous amount lies in the

Table 44. Recommended Daily Dietary Allowances

	Age, years	Weight, kg	Weight, (lb)	Height, cm	Height, (in.)	Calories	Protein, gm	Calcium, gm	Iron, mg	Vitamin A, I.U.	Thiamine, mg	Riboflavin, mg	Niacin, mg equiv.	Ascorbic Acid, mg	Vitamin D, I.U.
Children	1–3	12	(27)	87	(34)	1300	40	1.0	7	2000	0.7	1.0	8	35	400
	4–6	18	(40)	109	(43)	1700	50	1.0	8	2500	0.9	1.3	11	50	400
	7–9	27	(59)	129	(51)	2100	60	1.0	10	3500	1.1	1.5	14	60	400
	10–12	36	(79)	144	(57)	2500	70	1.2	12	4500	1.3	1.8	17	75	400
Boys	13–15	49	(108)	163	(64)	3100	85	1.4	15	5000	1.6	2.1	21	90	400
	16–19	63	(139)	175	(69)	3600	100	1.4	15	5000	1.8	2.5	25	100	400
Girls	13–15	49	(108)	160	(63)	2600	80	1.3	15	5000	1.3	2.0	17	80	400
	16–19	54	(120)	162	(64)	2400	75	1.3	15	5000	1.2	1.9	16	80	400

Recommended Dietary Allowances, Revised 1958. Publ. 589. Food and Nutrition Board, Washington 25, D.C., p. 15.



20. Daily calcium retention by preschool children on different levels of from milk. (Adapted from Outhouse et. al., *J. Nutrition* **17**: 205, 1939.)

ral feeling that the calcium stores of children should be well ed. Also, the efficiency with which calcium is utilized varies ly among individual children. The intake of 1 gm daily will for individual variation in utilization and still spare some for ge.

ow well do diets provide the recommended 1 gm daily of cal- in actual practice? Surveys of food habits indicate that many dren do not get that much. The nutrition histories of 58 Denver dren between age 1 and 5 years, showed half the children to have than $\frac{3}{4}$ gm of calcium daily; half the children were drinking less a pint of milk each day which is the chief source of calcium in diet.

study done in Canada disclosed that 158 preschool children se dietaries were evaluated frequently consumed less than the mmended 1 gm of calcium daily. The physical effect of the low ke was investigated. X-ray examination of the wrists revealed equate calcification and poor growth in 30 per cent of the dren on diets containing less than 1 gm of calcium daily (*1*).

We would like further evaluation of the calcium needs of the pre- ol child: the effects of a low intake, and further assessment of the mum intake.

on. Recommended Allowance for iron for the preschool child .3 to 0.4 mg per kg of body weight or in terms of total intake for

the day, 7 mg for children one to 3 years, and 8 mg for those 4 to
years.

The amount of iron needed daily has been determined for the m
part by balance studies. Another approach is that of adding toget
the estimated amounts of the mineral used for growth, maintenan
and storage. Johnston at Cornell University computed the iron
quirement of children in that way, using as a basis findings from
studies and others in the literature (Table 45). Growth needs w
predicted from increases in body weight and blood volume; requi
ment for maintenance was estimated from day to day losses in bo
excretions. The storage needs were computed by subtracting fr

Table 45. Iron Requirement of Children

Function	5 years of age		10 years of ag	
	Boys mg/day	Girls mg/day	Boys mg/day	Girl mg/d
Growth	0.2	0.3	0.4	0.
Maintenance	0.3	0.3	0.4	0.
Storage	0.1	0.1	0.2	0.
Total to absorb	0.6	0.7	1.0	1.
Food-iron required	6.0	7.0	7.0	9.
National Research Council allowance	8.0	8.0	12.0	12.

Adapted from Johnston, *J. Am. Dietet. Assoc.* **29**: 760, 1953.

the estimated store of iron in the adult (about 1300 mg), the estimat
store of the 2 year old (about 100 mg), and assuming the differen
(1200 mg) to be the amount to be stored between 2 years of age a
adulthood. It was presumed that smaller children would be able
contribute less to the total needed accumulation of iron than th
who are older. It was assumed accordingly that one-eighth of t
total amount would be stored between the ages of 2 and 6, leavi
seven-eights for the years between 6 years and adulthood. In ord
to retain 0.1 mg daily, which was the estimated allotment to the p
school years, an iron intake of 6 to 7 mg daily was estimated to
necessary, making allowance for poor absorption of iron from fo
(approximately 10 per cent).

It is not easy to supply the 7 to 8 mg of iron recommended da
unless some iron-rich foods are included in the day's menu. Eg
meats, particularly liver, and green vegetables can be counted on
provide 1 mg or more of iron in a child's serving. Enriched a
whole grain bread supply approximately $\frac{1}{2}$ mg per slice and cere

n ½ to 1 mg per serving. One and one-half pints of milk provide ng. Fruits provide some iron, most of them less than ½ mg per ing. Summing the rough estimate of iron from foods that would y be in a *good* diet for a day, it amounts to around 7 to 8 mg.

o children's diets meet the Recommended Allowance? In the y of the Denver children frequently referred to already, 75 per of the children between 2½ and 5 years had intakes of iron that e less than the Recommended Allowance, which is a contrast to first 2½ years when the intake, bolstered by specially prepared y foods, particularly cereals, adequately provided the recom- ded amount. Hemoglobin and erythrocyte values were within limits recognized as normal for healthy preschool children despite ntake of iron less than the Recommended Allowance by a majority he children. We need not interpret this finding to suggest that Recommended Allowance be lowered. The children studied had a generous intake of iron in the years preceding this period. p, we are well aware of the adjustment capacity of the body in ntaining a normal state despite nutrient intakes that are less than irable.

eating habits of the preschool child

t is natural for children of this age to vary in their eating habits n day to day, and from meal to meal. Their preferences for kind well as amount of food may be quite unpredictable. Such vacil- ons are recognized as part of developing childhood.

llowing some choice of food by nursery school children has met h good success. Children were found to increase their food in- e and to have fewer eating problems when some departure from t menu was allowed. A choice as simple as the selection between vegetables was found to bring about better habits of eating and oyment of food.

he unusual experiments of Davis must be mentioned in connection h children making their own food selections (*3*). She allowed ly weaned infants ranging in age from 7 to 9 months to select r own diet from a variety of natural foods, placed within their h. All foods available to the children were excellent in nutritive ue. They were provided from ten groups of foods including ts (muscles cuts), glandular organs, sea food (haddock), cereals ole grain wheat and barley, oatmeal, yellow corn meal, and rye ers), bone products (bone marrow and bone jelly, containing ble bone substances, made by boiling veal bones in water), eggs, k, fruits, vegetables, and sea salt. During the year-long observa-

tions it was noted that the children had a tendency to select certa foods in "waves," eating large quantities of a favored food at o time, very little if any at all at another time. The children nourish themselves well; the foods available to them were all of good nutriti quality. This study and subsequent ones that Davis did with old children reveal that children, with full responsibility for their ow selection of amount and kind of food from a variety set before the vary their preferences in unpredictable ways.

During the preschool years children have definite food likes an dislikes. There are certain characteristics of foods that tend to i fluence a child's reaction to them. Of course, there are marked ind vidual differences but in general as Lowenberg (*4*) has pointed ou preschool children prefer mild-flavored foods; those with a soft, jell like texture; and those that are lukewarm in temperature. Fing foods are popular with them, and colorful foods hold a special appe

Factors in the environment contribute to the good eating habits children. An attitude of expecting the child to eat and recognizi *that the child himself has something to contribute to his nutriti program* makes for good progress. Foods are more acceptable to th child if served in amounts suitable to him, with an awareness of h food preferences, his appetite, and his physical and emotional wel being at the time. The atmosphere during meal time should b pleasant; the chair on which he sits, the table from which he eats, an the utensils which he uses should be the right size to make eating eas and comfortable for him.

The preschool child is much interested in his environment, more s than in his food, a contrast from the babyhood he has just outgrown The mother who is forewarned of this lagging interest will not b alarmed at the change but will recognize it as a natural occurrence.

Refusing to eat is a weapon of strength for the child who is per mitted to use it. The attention commanded from concerned adult contributes to the power of the tool. Refusals sometimes are initiate by the child when he is forced to eat when ill or overtired.

Foods for the day

A general pattern of foods for a good daily diet for the preschoo child is presented in Fig. 121 (*5*).

The School Child and Adolescent

To be well nourished is one of the rights of childhood. The re sponsibility of turning this right into a reality rests with the parent

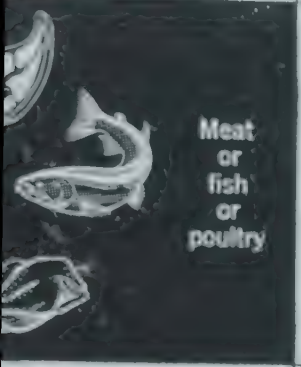
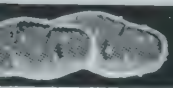
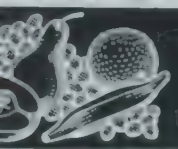
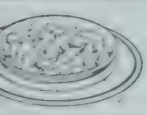
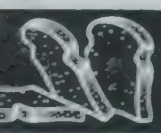
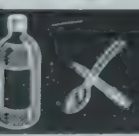
Foods	Amounts	Comments
 Milk	1 quart	Many children do not have this capacity at the preschool age. If your child does not, let him drink what he wants and try to get in more by using it in cooking.
 Meat or fish or poultry	1 serving	Beef, lamb, pork, poultry, fish or liver may be used. Occasionally cheese may be substituted for a serving of meat. (For an average serving at this age, nutritionists sometimes estimate about one level tablespoon of meat or vegetables per year of age. But this is no hard and fast rule. In serving food to a young child, put on his plate only what you think he will eat).
 Egg	1	
 Potatoes	1 average serving	
 Vegetables	1 or 2 average servings of green or yellow	Suggestions: Carrots, Tomatoes, Celery Spinach, Cabbage, Lettuce Green beans, Squash, Green peas Beets, Broccoli, Green peppers
 Fruits	2 average servings	One of these to be orange or grapefruit for vitamin C
 Cereal	1 average serving	Whole-grain or enriched
 Bread	3 slices	Whole-grain or enriched
 Butter or fortified margarine	2 tbsp.	
 Vitamin D supplement	As recommended by physician	

Fig. 121. Food for the day for the preschool child.

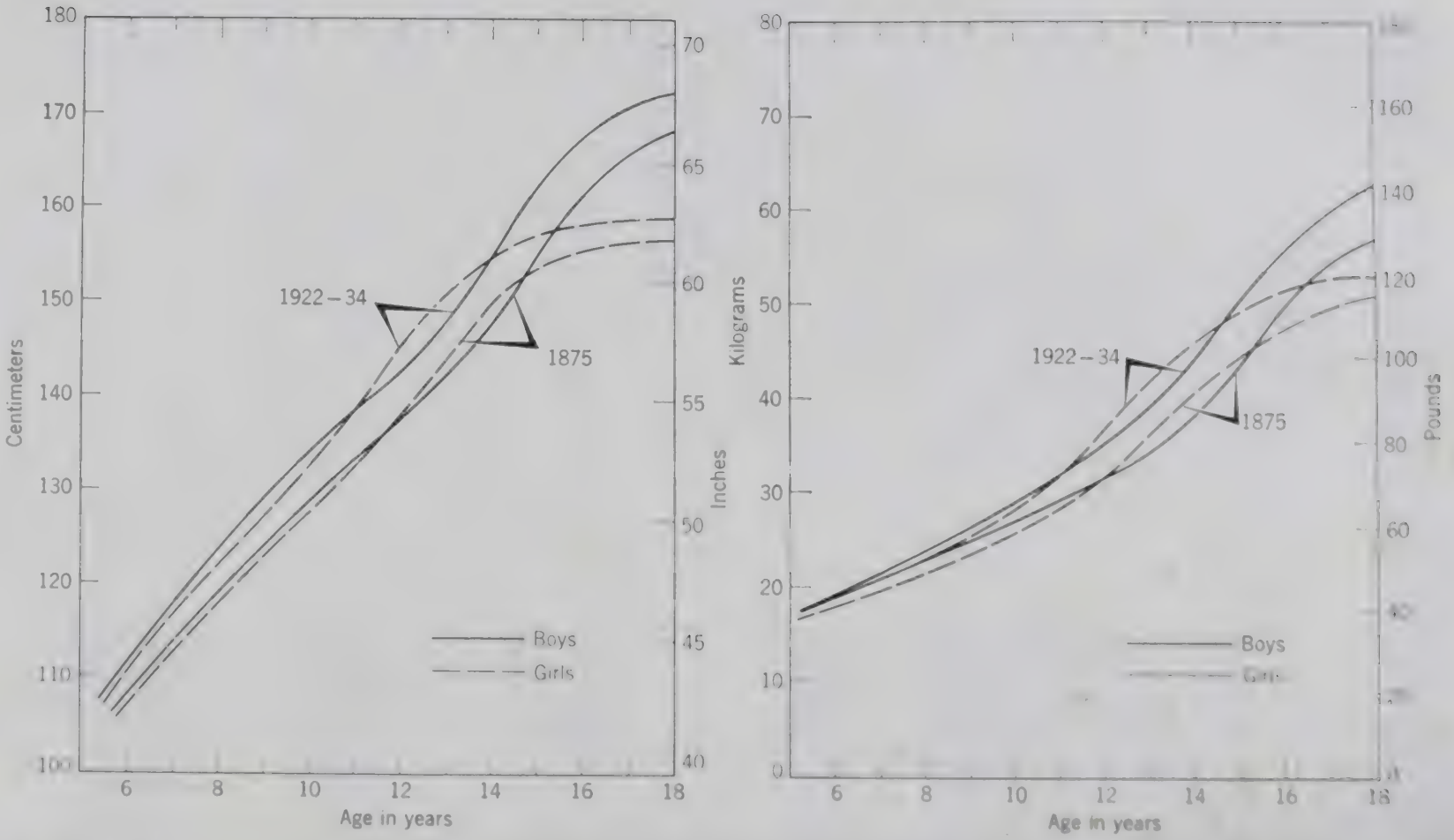


Fig. 122. Heights and weights of boys and girls in 2 periods about 50 years apart, Boston and vicinity. (Courtesy Harba

by teachers, school nurses, scout and recreation leaders, in fact, o are interested in the welfare of children.

surements of children in areas of the United States repeated tion after generation reveal that children are growing taller and st instances heavier in each succeeding generation. Figure 121 the height and weight of boys and girls in Boston and vicinity periods about 50 years apart. One of the factors responsible pproved growth is most likely better nutrition. In addition, im- d housing and sanitary conditions, increased immunization t disease, and better medical care have also contributed to g it possible for children to be "free to grow" unhampered by ng environmental factors.

onal needs

adequate nutrition in childhood, the diet must provide sufficient nts for building new tissue (*16*). The rate of growth deter- the amount needed for this purpose. The nutrient need for th is in addition to the needs for energy, regulating body func- and repair of tissue already formed. Children who are well- shed reflect their state of well-being in their general appearance tality and fitness, their good posture, and well-developed mus- ure (Fig. 123).

the years from 7 to 10 growth continues at a steady pace, fol- l by marked acceleration during the preadolescent period. The th spurt in boys begins around 13 to 15 years and in girls around 11 years. Both boys and girls continue to grow rapidly for years during the adolescent period. The rate then tapers off to elatively small gains characteristic of early adulthood as final size is approached.

ring the span of years from 7 to 20 when the young child grows young adult, the total daily nutrient needs increase with each ce in age (Table 44). As teen-agers, boys have higher nutri- requirements than at any other time in their life. Girls have ner requirement than at any earlier time but less than the recom- ations for women during pregnancy and lactation. The needs adolescent are influenced greatly by their rapid growth. As ony structure outstrips the musculature in rate of growth, the rbial awkwardness of the age appears.

can judge the adequacy of the energy intake of individual chil- most readily by observing their patterns of growth and the nt of muscle and fat they have. If the growth rate seems to be l for that individual and the child has firm muscles sufficiently



Fig. 123. Well-nourished 12-year-old girl.

well padded with fat, it can be concluded that caloric needs are b
met. We must be prepared to expect tremendously wide differ
among children in their growth patterns, with each still bei
healthy individual. For most children, *what the appetite dema*
a fairly reliable guide to satisfying energy requirements.

The recommendations of the National Research Council for
energy intake are intended to serve for individual children as app
mate guides only, and are most useful when applied to groups of
dren (Table 44). The wide variation in body size and rate of gr
during the years of adolescence have made it particularly difficu
establish caloric allowances that will not penalize some childre
being too limited and at the same time prove more than generou
others.

The recommendation for boys 13 to 15 years is 3100 Calories

continuing rapid growth in the 16 to 19 year period, 3600
es. For girls, 13 to 15 years, 2600 Calories are recommended;
growth tapering off in the 16 to 19 year period the allowance is
ased to 2400 Calories.

s not so easy to assess the adequacy of the protein, mineral, and
n intake as it is the energy. We use as a guide for evaluation
quantity of nutrients provided in the diet the National Research
il Recommended Allowances. In establishing the NRC values
necessary to bolster the few available research studies of some
nts with the best judgment of informed nutritionists. We use
RC Recommended Allowances with the belief that they have
made sufficiently generous to satisfy the needs of the majority of
en.

habits

equacy of food intake. To improve the food habits of children
ust first know what they eat, the shortcomings and good points
ir usual food intake. As a rule when children start to school
enter an era of making more food choices on their own. By
ge time they wish, as a rule, to exercise full authority in matters
at they will and will not eat.

ecent years dietary studies of school age and adolescent children
st sections of this country have been made (*5*, *7*, *21*, *26*, *28*, *30*,
4). States have cooperated with each other and with federal
es, (the U.S. Department of Agriculture and the U.S. Public
n Service), in observations that are sufficiently extensive to give
picture of the food consumption patterns of children in the
d States at this period.

hese countrywide dietary surveys, certain nutrients in the diet
to meet the NRC recommendations more commonly than
, whereas certain others were characteristically provided in suffi-
amounts to meet the recommendations. Calcium, ascorbic acid,
itamin A meet the NRC recommendations least well. Iron, in
on, in the diet of teen-age girls commonly failed to meet the
sted allowance for them. Inadequate consumption of milk,
fruits, and other ascorbic acid-rich foods, and green and yellow
ables was chiefly responsible for the nutrient shortages. Protein
dequate in the diets more frequently than any other nutrient.

tors influencing food habits. There are circumstances in the
of children that influence their food habits in certain almost pre-
le patterns. Age, sex, family income, food supply, family tradi-
nd cultural factors are among these determining factors.

Age and sex. Younger children are found to eat more adeq diets than teen-agers (*7, 21, 28, 31, 34*). In studies of school chil in New York State, the elementary children had better food ha than children at the secondary level. The same was found to be t in similar surveys in Louisiana. In an analysis of family diets in N York State, the food records of children under 10 years were the m adequate; those of adolescent girls the least. The diets of Iowa g ranked in a similar fashion; those of the younger girls commonly m the Recommended Allowances for all but one nutrient, and that v calcium, whereas girls over 12 years of age tended to have diets which most of the nutrients were in short supply. Connecticut c dren too showed a similar pattern; the diets of the 11-year olds w somewhat better than those of children 12 to 14 years of age.

There is little difference between the adequacy of the diets of bo and girls at the younger age levels. However, by adolescence bo consume diets that meet the Recommended Allowances more satisf torily than do girls. In fact, teen-age girls do least well of all child in the adequacy of their food intake.

Fear of "getting fat" seems to be conceded as the reason adolesc girls tend to curb their food intake. Unfortunately, this "cutt back" occurs at a time when the nutrient need is on the increa Milk is one of the foods commonly sacrificed. This is borne out i study of the milk-drinking habits of Alabama school children. G were found to curtail their milk intake sharply in the teen years; bo on the other hand, changed their milk drinking habits very little teen-agers (Fig. 124).

Family income. Higher incomes tend to favor more adequate di for the children of the family (*14, 22, 32*). In rural Wisconsin, ch dren living in good farming areas had more adequate diets than th living in a poor soil region. In two Pennsylvania communities, o an industrial, the other a college town, the diets of the children families of the higher income brackets in both locations were as a r more nearly adequate than in families of lesser means.

An examination of the dietary practices of private and public sch children in New York City adds further evidence that family inco makes a difference. The diets of the private school children we higher in nutritive quality than those of children attending pub school. In like manner, the diets of children attending acade schools were found to be more nearly adequate than the diets of th enrolled in vocational schools.

We should not leave the discussion of the influence of family come on the quality of the diets of children, with any possible i



124. Milk drinking habits of school children. (Courtesy Meyer, *J. Am. etic Assoc.* **33**: 485, 1957.)

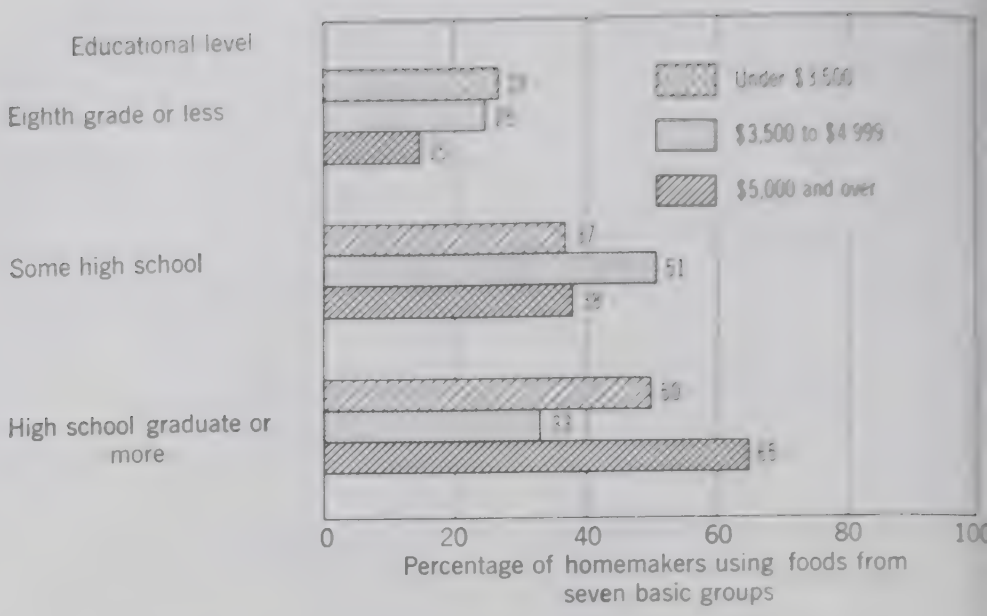


Fig. 125. Adequacy of feeding practices of homemakers with various le of education as related to income. (Adapted from Young et. al., *J. Am. Di Assoc.* **32**: 324, 1956.)

ference that sufficient money assures an adequate diet. That wo be an erroneous conception. Extensive studies of the food habits the people of the United States reveal that at each income level ab subsistence, some families are eating diets of good quality, some choosing poor diets (*4*).

In a revealing study the amount of formal education of the hon maker and income of the family were examined in relation to adequacy of her practices in feeding the family. Both had an fluence, but the influence of the educational level was actually grea than that of income (Fig. 125). Within an income bracket be feeding of the family paralleled additional years of schooling of homemaker.

Family traditions and cultural factors. Less tangible than the fact influencing food habits which have been discussed, but neverthel equally as real are family traditions and cultural background of individual. Whatever it may be that prompts people to eat as th do, whether it be religion, availability of food, the practices of th forebears, or even prejudices that may have developed, their est lished eating customs are an intimate part of them. Behavior in matter of food is held to more tenaciously than many of our ot habits. The oneness of a person's customs of eating with the pers himself gives a feeling of security, a sense of well-being, and of "rig

s in the world" when permitted to follow those customs, on the er hand, inability to procure the foods or to prepare them as de- d engenders frustration.

Recognition of the fundamental nature of the eating habits of ple makes for understanding of the natural barriers to change that t. On occasion we may feel that refusal of unfamiliar food by sons in need is reprehensible and unappreciative on their part, ereas the response most likely is deep-seated and can only be nged by time and wise methods of education. The habits are most ply entrenched among people living in areas little touched by the side where the same food supply has prevailed for years. On the er hand, people who travel widely learn to enjoy many foods new them and familiar foods served in unfamiliar ways.

Supplements to the diet. Through the years it has interested nutri- ists to find out how the addition of certain foods to the diet of ldren influences their physical status. Improvement in rate of wth was the criterion most commonly used for assessing the bene- al effect of the added nutrients. No change in growth was in- preted as evidence that the current food intake supplied sufficient ounts of the dietary essentials and providing more in the added d made no difference.

Adequacy of the food intake of children has been assessed by noting nges in growth after the addition of certain foods to the diet. hool feeding programs in children's institutions, provided avenues supplemental feeding. There are certain problems involved in ting precise information from such studies. It is difficult to find about the "usual" diet and practically impossible to control it en children are living at home. It can be done with more ease en children live in institutions. The role of health, psychological uences, and whims of the appetite cannot be ruled out as factors the results. Nevertheless, these early observations did yield results ich, without a doubt, led to better feeding of children, which, after is the ultimate goal of such nutrition studies.

Among the early recorded experiences was the one of Mann in gland. He observed 350 boys over a period of 2 years; one group s kept on the usual diet and used a control. An addition of ap- oximately 336 Calories was made to the usual diet of each of 4 ups, as a pint of milk to one, and sugar, margarine, and butter to other three respectively. To a fifth group, casein equivalent to amount supplied by a pint of milk was used, and to the sixth up water cress was given. The supplement of a pint of milk pro- ed the greatest growth, both in height and in weight (*17*).

Milk was the best supplement in the foregoing study; it has al always been found to be so, however. Chaney (*3*) found orange juic to promote better growth than milk when fed to over 200 Californi school children who came from families of the so-called higher eco nomic levels. On the other hand, for children with less adequat diets, milk had a greater growth effect than fruits (*18*).

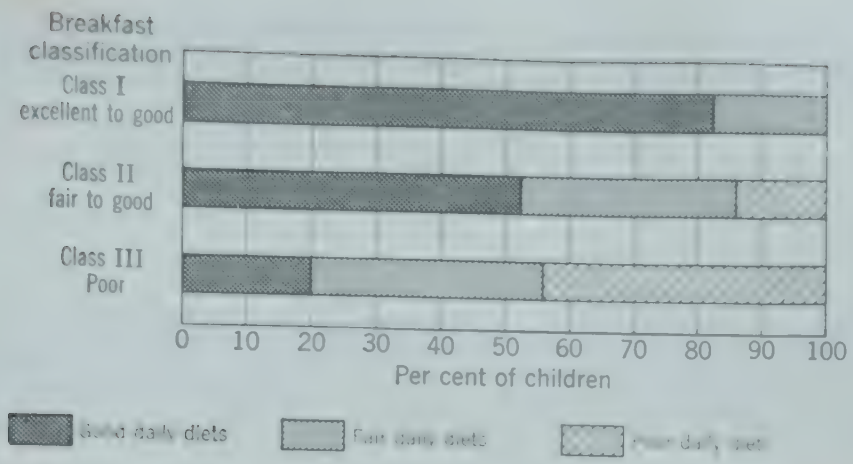
A finding that has significant bearing on the importance of provid ing an adequate diet for children is that as diets become more adequate the consumption of sugar decreases. Macy and her collaborator (*15*) made this observation during their extensive investigations o nutrition during childhood. As the study progressed, the diets wer adjusted as to quantity and quality to suit the needs of each partic ular child. Sugar could be used voluntarily as much or as little a desired, and as the diets became more adequate, each child ate les sugar. This scientific finding confirms our belief from casual, every day observations at home, at school, and at the county fair, that good diets are the best preventive to an abnormal craving for sweets.

The importance of breakfast

Breakfast warrants special emphasis in view of the fact that it is the meal of the day most frequently skipped—not only by children bu by adults as well. Furthermore, if not omitted entirely, it is apt to be scanty and hurried.

The breakfast problem is not new. In 1918 Roberts surveyed the dietary habits of 6000 preschool children in Gary, Indiana, finding one-third of them to have eaten no breakfast, or one that was wholly inadequate such as *one cup of coffee* or *one cup of coffee and a few cookies* (*17*). It is evident that poor breakfast habits begin at an early age.

Incidence of poor breakfasts. A roll call of recent studies of break fast habits of children gives ample evidence that many children are eating no breakfast at all or one that is inadequate. From Alabama to Minnesota, and California to Connecticut, including the states in between, the story is much the same (*11*, *12*, *21*, *24*, *25*, *27*). A study in three rural schools in Alabama revealed that one-seventh of the children were omitting breakfast at least once each week. In a survey of eating habits of children in Rochester, Minnesota, a common prob lem was the inadequate breakfast. The habits of 10,144 California students in 81 junior and senior high schools were obtained by ques tionnaire. Six per cent of the young people indicated that they never eat breakfast, 26 per cent that they do sometimes. The reason given by over half of those not eating breakfast or doing so irregularly was



126. Comparison of daily diet ratings with breakfast classification. (Courtesy Sidwell and Eppright, *J. Home Econ.* **45**: 404, 1953.)

k of time. In a Connecticut study, rural eighth graders omitted ore meals than any of the other children in grades 5 through 8, from th town and country. Breakfast was the meal that over half of m skipped. Twelve per cent of 1300 Indiana children, 9 to 14 ars of age, were found to be eating no breakfast or having coffee y. One-half to two-thirds of the 1188 Iowa school children whose od habits were studied had predominantly poor breakfasts.

Effects of poor breakfasts. Research studies confirm the belief that most children a good morning meal is essential if the food intake the day is to be adequate. Only one child in five made up in the ner meals of the day the nutrient deficit caused by a poor breakfast ig. 126). Those who omit breakfast entirely invariably have a less equate food intake for the day than those who eat a morning meal. the other hand, when all of the breakfasts eaten were adequate, in tudy of the food habits of Montana students, the total day's food ake likewise provided the needed nutrients in better supply than nen none was adequate (Fig. 127).

Poor breakfasts interfere with achievement in school (*9, 20*). In a dy in Toronto, Canada, teachers reported that children who ate dequate breakfasts appeared more fatigued and were less attentive their school work than those who had eaten better breakfasts. velve- to 14-year-old boys in an Iowa study reacted in a like man-; they were restless and inattentive in the late morning hours when y had eaten no breakfast. The same boys, when they ate breakt, improved in scholastic achievement and had sufficient energy for rside activity.

Findings from a contributive series of studies at the University of

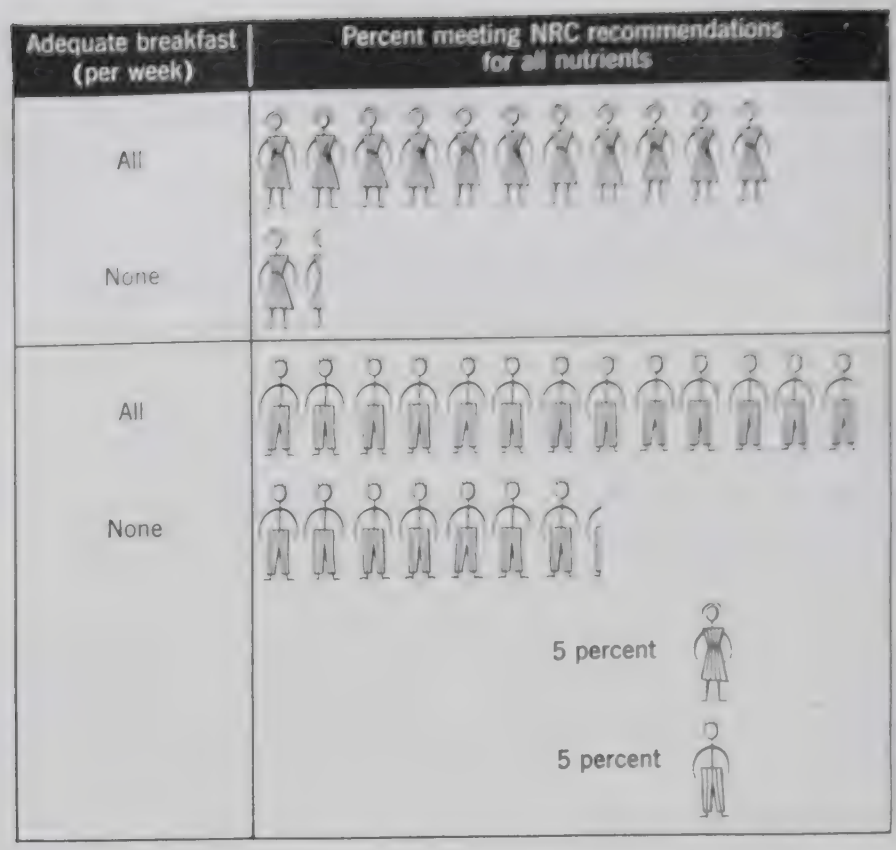


Fig. 127: Effect of adequacy of breakfasts on success in meeting NRC Recom mended Allowances for the day. (Adapted from Odland et. al., *J. Am. Dietet Assoc.* **31**: 1134, 1955.)

Iowa give further evidence that whether or not you eat breakfast, an the quality of the breakfast eaten *does make a difference* with mos people (*20*). The observations were with young adults, for the mos part; some with adolescent boys. We are including these studies i the discussion of children's food habits for the findings are pertinen and such observations with children, other than adolescent boys, hav not been done.

The general plan of the studies included feeding breakfasts of dif ferent nutritive quality, and in some series, omitting the meal entirely accompanied by measurements of the effect on certain physical an mental responses. The *basic breakfast*, an adequate morning mea providing one-fourth of the daily caloric requirement (600 Calorie for the women; 750 for the men), contained the following foods: fruit cereal, whole milk, sugar, enriched white bread, butter, and jelly The *heavy breakfast* supplied 1000 Calories for the women, 1200 fo the men, and provided in addition to the foods in the basic breakfas the following: bacon, cream, egg, and jelly (Fig. 128). With

kfast no food was eaten between 8 o'clock in the evening and
n the next day. The measurements of behavior included *neuro-*
cular tremor, *maximum work output*, and *reaction time*.
euromuscular tremor was recorded from the outstretched right
, unsupported (except by voluntary resistance against the force

Food	Basic breakfast gm measure	Heavy breakfast gm measure
Fruit	100 (1 ea)	100 (1 ea)
Cereal	30 (1 cup)	30 (1 cup)
Egg		50 (1 ea)
Bacon		20 (2 sl)
Bread	60 (2½ sl)	60 (2½ sl)
Butter	8 (1 pat)	16 (2 pat)
Jelly		20 (1 T)
Cream		60 (2 oz)
Milk, whole	360 (1½ gl)	240 (1 gl)
Sugar	5 (1 T)	10 (2 T)

. 128. Breakfast patterns used in The University of Iowa studies. (Adapted
om Daum et al., *J. Am. Dietet. Assoc.* **26**: 504, 1950.)



Fig. 129. Determination of neuromuscular tremor magnitude. Index finger of unsupported arm lightly touches a pin. Tremor is thus transferred into an electric current which is amplified sufficiently to activate a recording pen. (Courtesy W. W. Tuttle, Dept. Physiology, College of Medicine, University of Iowa.)

of gravity) before and after one minute of strenuous exercise on a bicycle ergometer (an ordinary bicycle with instrument for measuring work output) (Fig. 129). Lower readings indicate less movement of the arm, and a more favorable response. Maximum work output was calculated from measurements taken as the subjects rode the bicycle ergometer at their maximum effort for one minute (Fig. 130). Reaction time to a stimulus of light was measured as the interval of time elapsing between the appearance of the light and the person's recognition of it, which he indicated by pressing a switch with the finger (Fig. 131). With reaction time, the shorter the time interval, the more favorable the response.

Effect of no breakfast. By all three measures of individual efficiency *no breakfast* had an unfavorable effect on most persons. The tremor magnitude was greater and the reaction time slower in all subjects

ed except adolescent boys. It is a tribute to the steady nerves and tness of the 12- to 14-year old fellows that these responses were nfluenced by omission of breakfast. All persons observed, includ- the boys, showed a decrease in maximum work output in the late rning hours when breakfast was omitted.

ffect of a cup of coffee. A cup of black coffee alone proved to be re detrimental to physical and mental efficiency than no breakfast all. In the Iowa studies 10 women, 18 to 25 years of age, were en black coffee without sugar. The tremor magnitude increased, maximum work output decreased, and in 45 per cent of the cases reaction time increased over those responses with no food or nk.

ffect of a heavy breakfast. A heavy breakfast decreased the maxi- m work output of the men studied but not of the adolescent boys. e men, 20 to 35 years of age, were fed a heavy breakfast of 1200 ories containing 38 to 40 gm of protein. In 75 per cent of the



. 130. Determination of maximum work output. Subject is shown riding a ycle ergometer (conventional bicycle with attachment for measuring work tput). (Courtesy W. W. Tuttle, Dept. Physiology, College of Medicine, niversity of Iowa.)



Fig. 131. Determination of reaction time—operator (shown at left) pres switch to flash light before subject in the next room. Subject (shown at righ has hand on response key which is pressed when light flashes. (Courtesy W. Tuttle, Dept. Physiology, College of Medicine, State University of Iowa.)

cases the men did significantly less work after eating the heavy breal fast than after the consumption of the regular basic breakfast of 7 Calories with 25 gm of protein. The other two indices of physi logical effect, tremor magnitude, and reaction time, registered difference with the two types of breakfasts. The adolescent bo with their high nutrient needs could handle the heavy breakfast wit out evidence of detraction from their efficiency.

Effect of amount of protein in the breakfast. Sufficient protein the breakfast helps to prevent that hungry feeling before lunc How much protein is enough to prevent the late forenoon lag? F young women 17 to 29 years of age a breakfast containing 23.2 g protein, with 19.5 gm fat, 45.8 gm carbohydrate, and providing 4 Calories, prevented hunger symptoms in all who ate it in a study at t University of Maine (*6*). The breakfast contained the followi foods:

		gm protein
Orange juice	½ cup	1.0
Eggs	2	12.2
Bread	2 slices	4.0
Butter	1 tsp.	0.0
Light cream	1 tbsp.	0.4
Skim milk	⅔ cup	5.7
Coffee	⅔ cup	...
		23.3

What is the physiological explanation for protein in the breakfa allaying sensations of hunger and weakness before noon-time? Breal

of equal caloric value, but low in protein content and high in fat rbohydrate, do not have this beneficial effect. The explanation n the difference in the effect the three foodstuffs have on the glucose level following the meal. Breakfasts sufficiently high in in content elevate the blood glucose level above the fasting level period of approximately 4 hours after the meal; meals low in in but high in fat and in carbohydrate elevate the level for only d 3 hours respectively. Sensations of hunger and a feeling of ness are associated with low blood sugar levels.

there an explanation for the length of time that the blood glucose ins elevated after eating isocaloric breakfasts, some high in pro- some in fat, and some in carbohydrate? There is an explana- the crux of which lies in the difference in the amount of glucose ng from the meal and the rate at which it enters the blood stream. r half the protein in an average diet can be used as carbohydrate. nters the blood stream slowly over an extended period because ain intermediary changes must be made before the protein can be as glucose in the blood. With fat only the glycerol portion, ch is considered to be about 10 per cent of the total, can be used arbohydrate. Fat elevates the blood glucose least of the three dstuffs. In the case of carbohydrate, it is more nearly ready to r the blood stream as blood sugar than the protein and fat. sequently, within the first hour after breakfast the blood glucose s to a peak but by the end of the second hour it has fallen almost he prebreakfast (fasting) level. By then with a high carbohydrate akfast, you are justified on a physiological basis in wanting to eat in.

et us examine again the amount of protein in the breakfast, this e in relation to holding the blood glucose level above the fasting ue for 3½ to 4 hours (*2*, *6*, *19*, *20*). The 23 gm of protein in the akfasts of the young women in Maine, cited earlier in relation to ying hunger, was sufficient to hold the blood glucose level above fasting value for 4 hours. Numerous studies in the literature con- that approximately that amount of protein is needed; 15 gm was nd to be insufficient in one study with young women to elevate the od glucose for 3½ to 4 hours; 22 gm was sufficient in another. In ervations with young men, 10 gm of protein was not enough, ereas 25 gm was an adequate amount.

Good breakfasts. Certain foods are commonly served for break- . That does not mean that other foods are not equally acceptable the morning meal, if they are wholesome and nutritious. It is sonable to expect the foods of the morning meal to provide from

¼ to ⅓ of the day's total nutritional requirements (with lunch and dinner each providing ⅓, and snacks the remainder). One pattern for an adequate breakfast for a school child includes the following foods:

Fruit
Whole-grain or enriched cereal
Egg or other protein food such as ham, sausage or bacon
Bread, whole wheat or enriched
Butter or fortified margarine
Milk

The role of snacks

Contribution to food intake. Eating between meals is not in itself an offense to good nutrition; the kind of food eaten and the practice of continuously nibbling may be. We must accept the fact that the majority of children do eat snacks. The foods eaten for between-meal snacks are found consistently to provide energy to a greater extent than essential nutrients (Table 46) (*8, 25*).

Table 46. Percentage of Total Day's Intake from Snacks

Age in Years	Boys				Girls			
	6–8	9–11	12–14	15+	6–8	9–11	12–14	15+
Calories	15	14	13	17	13	15	16	16
Protein	9	9	8	11	8	9	11	10
Calcium	11	9	11	14	9	10	12	13
Iron	10	9	8	11	9	10	11	10
Vitamin A value	8	7	6	8	7	8	9	8
Ascorbic acid	14	14	11	12	14	15	13	11
Thiamine	12	12	11	15	12	13	13	13
Riboflavin	11	11	12	15	10	12	14	14
Niacin	9	8	8	11	8	9	9	8

Adapted from Eppright and Swanson, *J. Am. Dietet. Assoc.* **31**, 257, 1955.

Unfortunately, snacks seem not to improve the diets that need improvement. Where the food intake was poor in quality, snacks contributed little to bolstering the nutrient content of the food for the day.

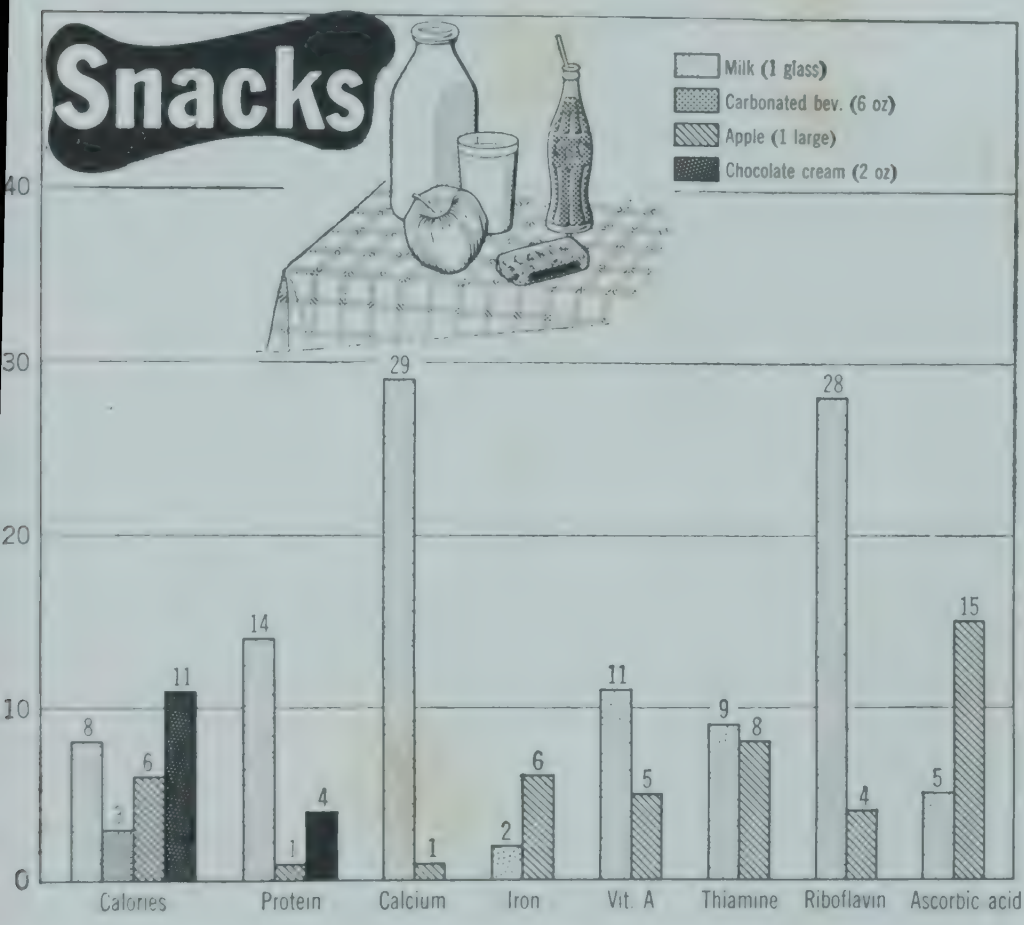
Snacking—a social custom. We recognize that between-meal snacks serve a dual function, first in providing a portion of the nutritional requirements of the day, and second in filling a social need. The gregarious aspect of snacking is no less important than the nutritional function. Members of groups, especially teen-agers, influence

hoices of one another through the tendency to follow the gang. an opportune situation to promote nutritious snacks as a popular tion.

ffect of snacks on meal-time eating. It is of interest to know ther eating snacks influences the quantity of food eaten at the fol ng meal or the total intake for the day. Milk given between ls to children ranging from 3 to 14 years was found not to hamper r appetites for the next meal (*33*).

With teen-age girls it has been noted that as the Calories from ks increase, the Calories from breakfasts decrease. The girls who sumed the most candy and soft drinks tended to eat the smallest kfasts (*10*).

nack foods. Good foods for snacks are those that provide at least reat a percentage of the day's total requirement for several of the ntial nutrients as for energy and are not high in satiety value. ure 132 illustrates the nutritive value of some common snack foods.



132. Percentage of NRC Recommended Allowance furnished by each of r snack foods for 7- to 9-year-old child.



Fig. 133. Enjoying a snack.

All milk products, fruits, and sandwiches are good for in-between meal eating (Fig. 133). Poor snack foods are those that provid empty calories, calories and little else. Foods such as pop, candy and crackerjack fall in that category. The nutritive value of po and chocolate creams is illustrated in Fig. 132. Concentrated swee satisfy the appetite quickly; in other words, they are high in satiet value, and jade the appetite.

The noon meal

The midday meal, whether eaten at school or at home, should pro vide approximately one-third of the day's total calories and nutrien needs. When the lunch is inadequate the total food intake for th

is apt to be inadequate also. We find the deficiencies caused by
or lunch are not supplied by the other meals or by snacks.

nch at school. The noon meal is eaten at school by an estimated
er cent of the children of school age in the United States (Fig.
. School feeding has been on the increase as judged by the ex-
of participation in the National School Lunch Program. In
a total of approximately 475 million lunches were served with
er cent the complete meal type (Type A); in 1954; 1661 million
e served with 76 per cent Type A; in 1957, 1777 million meals
e served with 98 per cent of them Type A meals; in 1958, 1883
ion lunches were served and 98 per cent were type A.

erving food at school is not a new venture. The practice was re-
ted long before the present-day feeding program was instigated.
he United States, school feeding in the early days was initiated by
ntary societies and women's clubs, and was confined to cities,
York, Philadelphia, and others. Today of course, it reaches
l and urban areas as well as cities.

chool feeding is worldwide in scope. A survey made in 1949–



Fig. 134. Children enjoying their school lunch.

1950 showed that in some countries a program had been organized o a nationwide scale, in others it was limited in extent (*23*). In mo countries some effort has been made at one time or another to pro vide some nourishment at school for the children.

Contributions of the school lunch. A child's lunch at school shou be a meal that will improve the nutritive value of his total food intak for the day. The complete meal-type lunch, providing approxi mately one-third of the nutritional needs for the day, contributes th share of nutrients generally expected of the noonday meal. If only a partial meal is served, to be effective, those foods should supplement the nutrients provided by the remainder of the day's diet. We know that it is an ill-advised practice to feed children at school the same foods provided in abundance in the family meals, and omit certain essential foods both at school and at home. It behooves persons who assume responsibility for school feeding in local areas to familiarize themselves with the prevailing food habits of families as a general guide for planning. Furthermore, the school lunch should provide for the child as good a meal as the one he would otherwise have had.

The school lunch is not only a means of providing nutritious food for children, but affords unique educational opportunities as well. Experiences in connection with the meal are natural situations for the teaching of certain health habits, the importance of good grooming, table manners, and nutrition. To fully realize the educational ad vantages, lunchroom practices may be related to classroom discussion and guidance in an integrated program. In this connection, we need to remind ourselves repeatedly that for the learning experiences to be effective, they must be geared to the suitable educational level of the children.

It may be that for some few children it is not in their best interest to have lunch at school even though the program be of the finest cali ber. We recognize that there are children who are readily over stimulated and who benefit from being away from their classmates for a period of quiet at noontime.

Children's enjoyment of the school lunch. Although nutritive qual ity is an essential yardstick for planning the school lunch menus, within that framework cognizance of the food likes and dislikes of the children contribute much to the success of the program. Active participation in phases of menu planning, followed through by serv ing foods that they have recommended themselves, improves eating habits and general enjoyment of meal time by the children.

It should be recognized too that children are sensitive to the quality of preparation of foods and the manner of serving. They like food

prepared but in simple ways, attractively but simply served, and
ounts suitable to their capacities. It has proved effective to take
ren behind scenes into the kitchen to see food in the process of
aration. First-hand experience with simple processes of food
aration has been found to whet disinterested appetites into ac-
ng certain disliked foods. On occasion we are wont to lose sight
e fact that the school lunch is for the child and approach our
lems on the thesis that the child is for the school lunch. Success
rtain to attend the program built around the child's needs and
ests.

utritive value of school lunches. Reference was made in a preced-
paragraph to the Type A complete lunch. The pattern for this
as described in the National School Lunch Act of 1946 and later
ifications specifies that one-third to one-half of the day's nutritive
s be provided and that at least the following foods be included:

Fluid whole milk, one-half pint.

A protein food such as two ounces (edible portion as served) of fresh
rocessed meat, poultry, fish, or cheese; or one-half cup cooked dry
, beans, or soybeans; or four tablespoons of peanut butter; or one egg.
be counted in meeting this requirement, these foods must be served in
ain dish or in a main dish and one other menu item.

Vegetables and/or fruit—a three-fourth cup serving consisting of two
nore vegetables or fruits, or both. Full-strength vegetable or fruit juice
be counted to meet not more than one-fourth cup of this requirement.

Bread, muffins, or other hot bread made of whole-grain cereal or en-
ed flour—one portion.

Butter or fortified margarine—2 teaspoons.

Do meals planned following the five point scheme listed provide
east one-third of the day's nutrient needs? Government research
rkers investigated that question (*29*). They found thiamine to be
t well supplied, followed by ascorbic acid. These findings indi-
e that we should pay special attention to including foods that pro-
e these vitamins when planning the school lunch menu.

A lunch without milk falls short of meeting the requirements of an
quate noonday meal. Calcium and riboflavin, in particular, and
otein, thiamine, and energy value also were reduced in amount by
omission of milk (Fig. 135).

Effect of school lunch on nutritional status. Some children improve
nutritional status when provided a lunch at school, others show no
nge in physical condition. It is apparent that we cannot antici-
e improvement in nutritional status unless the lunch provides es-
tial nutrients that would otherwise be deficient in the total day's

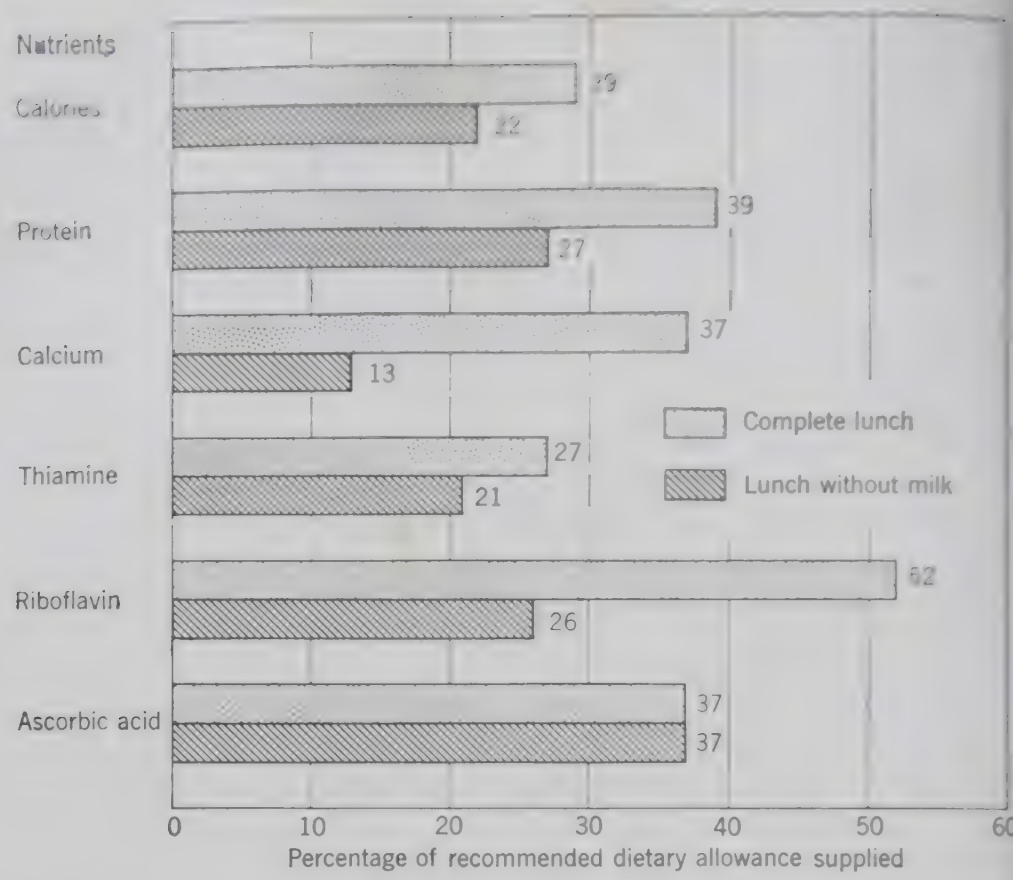


Fig. 135. Nutritive value of school lunches served, with and without mi Values are expressed in terms of percentages of the recommended dietary allo ances of the child 10 to 12 years old. (From Meyer et. al., *J. Am. Dietet. Ass* **27**: 844, 1951.)

diet. Furthermore, children who are already well nourished cann be expected to show striking improvement with school feeding.

An extensive study over a period of 5 years in Florida showed t school lunch to be of distinct benefit to the physical well-being the children (*1*). The children showed symptoms of poor nutriti at the outset. During the school year these symptoms lessene Notable among the changes during the period when the children we having lunch at school was the increase in hemoglobin values; duri vacation the levels lowered again. Height and weight measuremer charted on the Wetzel grid showed an advance in developmental lev during the feeding period. On the other hand, children who were fairly good physical condition prior to the program, as observed two Maryland elementary schools, showed little difference in phys cal status with school feeding (*29*).

In a Pennsylvania study, the only children who showed improv

at following their participation in the school lunch program were se whose lunches had been carefully planned by someone trained nutrition and dietetics, who took care that the noon meal supple- ted those served at home, making for a more adequate total daily d intake (*13*). The nutritive value of the lunches was computed, the nutritional status of the children assessed at intervals, includ- medical and dental examinations.

evening meal

The evening meal may also fail to supply its fair share of the day's tary nutrients. Some families have their big meal for the day at on with left-overs and snacks in the evening. Children who eat ch away from home, and one that is only partially adequate, have le opportunity to make up the deficiencies in the evening in such ilies. A good evening meal, like breakfast and lunch, is essential assuring an adequate food intake for the day.

Suggestions for Good Diets for School Children

Helpful suggestions are available in government publications for oviding adequate meals for children. The sample day's meals is om "Nutrition and Healthy Growth:"

A Sample Day's Meals for a 10-Year-Old

BREAKFAST

Tomato juice (¾ cup)
Hot whole-wheat cereal (⅔ cup)
with milk (½ cup)
Toast (2 slices) with butter or
fortified margarine (2 teaspoonfuls)
Milk (½ pint)

LUNCH

(If served at school or at home)
Creamed eggs (¾ cup)
Green beans (½ cup) with butter
or fortified margarine (1 teaspoonful)
Oatmeal muffins (2) with butter or
fortified margarine (2 teaspoonfuls)
Milk (½ pint)

(If brought from home)
Sandwich—peanut butter and raw carrot
on buttered whole-grain or enriched bread

Supplemented at school by—
Orange
Milk soup (1 cup) or cocoa (1 cup)

Sandwich—chopped dried fruit on buttered whole-grain or enriched bread
Supplemented at school by—
Orange
Milk soup (1 cup) or cocoa (1 cup)

DINNER

Meat loaf (1 serving)
Scalloped potatoes (⅔ cup)
Coleslaw with red and green peppers (½ cup)
Whole wheat bread or enriched bread (2 slices) with butter or fortified margarine (2 tablespoonfuls)
Applesauce (½ cup)
Molasses cookies (2 thin)
Milk (½ pint)

Snacks of fruit, milk, graham crackers.

A Sample Day's Meals for an Adolescent Boy

BREAKFAST

Orange
Shredded wheat with milk (½ cup)
Eggs (2)
Muffins (3) with butter or fortified margarine (2 tablespoonfuls) and marmalade (2 tablespoonfuls)
Cocoa (2 cups)

LUNCH

Macaroni and cheese (2 large servings)
Sliced tomatoes (2) with mayonnaise (1 tablespoonful)
Rye bread (2 medium slices) with butter or fortified margarine (1 tablespoonful)
Baked apple (1 large) with sugar (1 tablespoonful) and cream (¼ cup)
Cookies (2 large)
Milk (½ pint)

DINNER

Pot roast of beef (large serving)
Baked potato with gravy
Cabbage (1 cup) with butter or fortified margarine (2 tablespoonfuls)

Whole wheat bread (2 medium slices) with
butter or fortified margarine (1 tablespoonful)
Rice milk pudding (2 servings)
Milk (½ pint)

Snacks of fruit, milk, cookies, sandwiches.

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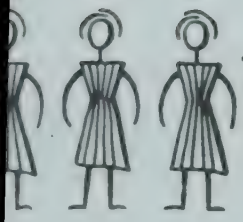


CHAPTER 24



Nutrition needs of special groups





Nutrition During Pregnancy

During pregnancy the diet deserves special consideration to make re that it will not be a limiting factor to the good health of both other and child (*17*). The influence of nutrition begins prior to nception and continues throughout the gestation period. Many lieve that the influence of nutrition on reproduction begins as early the childhood years, when the character of the skeletal structure being determined and the functional capacities of the organs and sues are being established.

Certain ill effects have been associated with maternal consumption a diet poor in nutritional quality. Toxemia in the mother and ematurity in the infant are found to be prevalent among women nsuming inadequate diets. Thirty-five per cent of the women with or diets, in a study of 186 mothers in Australia, suffered toxemia, hereas the incidence was only 4 per cent among those selecting a od diet. The incidence of prematurity among their infants was per cent for mothers eating poor diets, none for those consuming od diets (Fig. 136). Additional evidence of the ill effects of a poor et comes from studies done in Canada and the United States (*2, 8*).

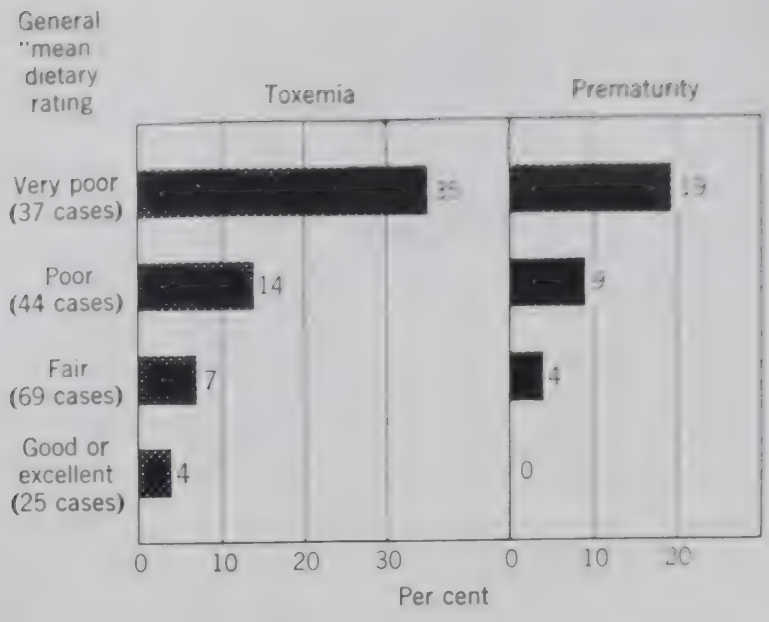


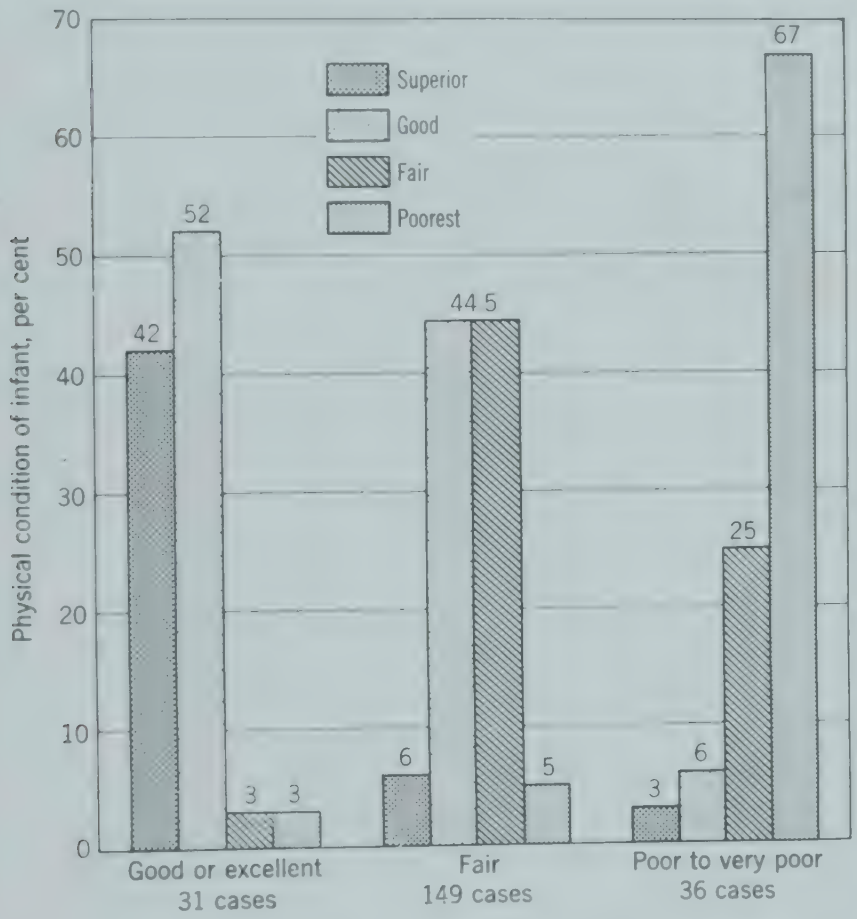
Fig. 136. Maternal diets in the latter half of pregnancy related to toxemia and prematurity. (From Woodhill, et. al., *Am. J. Obstet. Gynec.* **70**: 987, 1955.)

Miscarriages, and premature and still births were more frequent if the maternal diet was inadequate. Illnesses and deaths resulting from the illnesses, were more frequent among infants under 6 months of age born to mothers eating poor diets.

It is apparent that a nutritionally inadequate diet during the prenatal period predisposes the infant to a poor physical condition and the mother to certain complications during pregnancy. It is logical to ask if, on the other hand, a good diet endows the infant with positive good health and the mother with added assurances of a successful pregnancy. The answer is in the affirmative. Burke and her colleagues at Harvard University found a definite all-over relationship between excellence of the mother's diet and superiority in the physical status of the newborn baby. This association of good maternal diet with the good health of the infant is shown graphically in Fig. 137. As for the mothers, they too fared better. Not only did they suffer fewer complications during pregnancy, but also had less difficulty during labor. Furthermore, the mother had better prospects of being able to nurse her infant if her diet had been of good quality during pregnancy (Fig. 138).

There is little doubt but that the long-time food habits of pregnant women, as well as their food intake day after day throughout the entire prenatal period, play a significant role in the health of mother and child. The first 8 weeks of pregnancy are of particular im-

nce for it is at this period that the fetal organs are being formed. e is some evidence that poor nutrition at this period may result alformations. We are concerned about the second half also se the major gain in weight of the fetus takes place during that d. At the beginning of the third trimester the fetal weight is oximately one-third the weight at full term, which means that e last one-third of the prenatal period around two-thirds of the fetal gain takes place. As a consequence the demands for build- aterials for the formation of new tissue are stepped up markedly. maternal diet must provide for the additional requirements. It d be recognized also that not only is the fetal tissue increasing in nt but also the mother too is experiencing a growth of certain s; the mammary glands, and accessory tissues supporting the , as well as certain other glands and tissues throughout the body ase in size during the prenatal period.



137. Relationship of prenatal nutrition to the physical condition of the in- at birth and within first 2 weeks of life. (From Burke, Beal, Kirkwood and rt. *Am. J. Obstet. Gynec.* **46**: 38, 1943.)

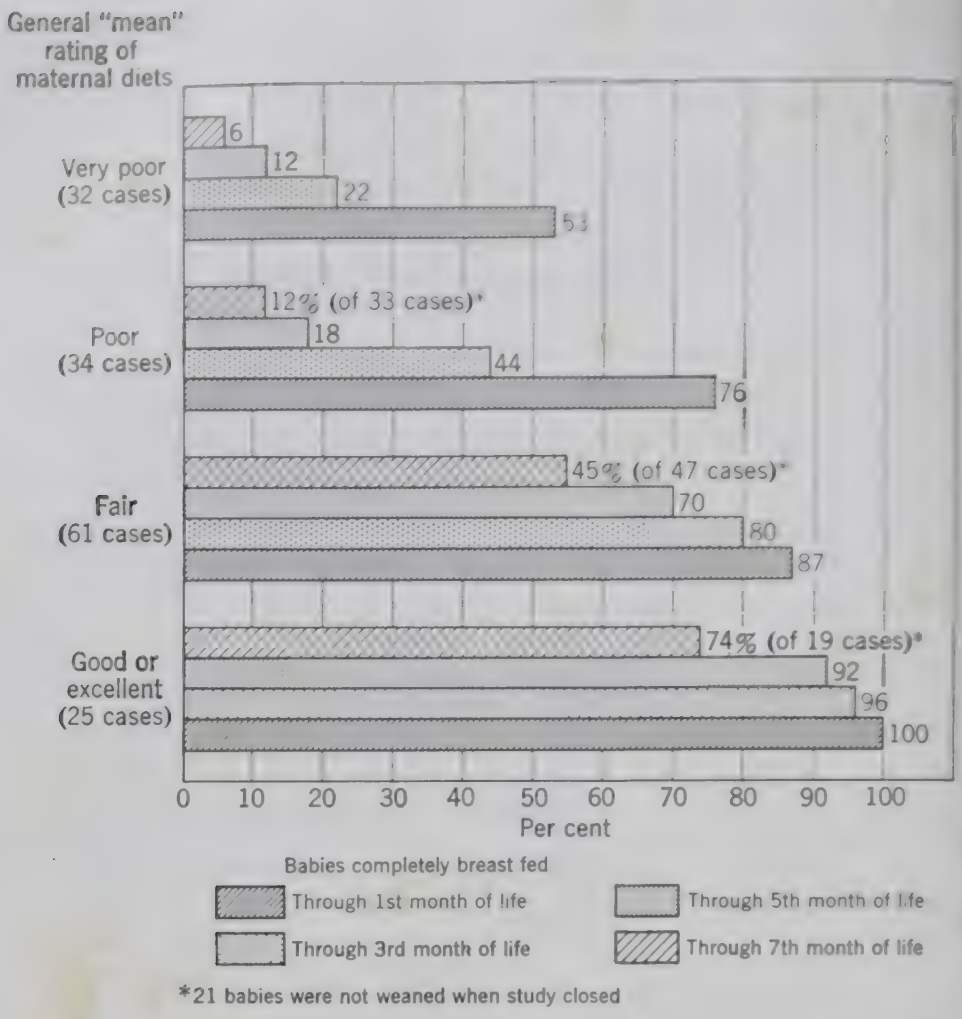


Fig. 138. Breast feeding related to maternal diet in the latter half of pregnan Percentage of babies completely breast fed in each diet group. (From Woodl et. al., *Am. J. Obstet. Gynec.*, **70**: 987, 1955.)

Calories

Calorie intake is of particular concern during pregnancy because its relationship to maternal weight gain. The pattern of gain a amount are significant to the well-being of the mother. During t first trimester, although the absolute increase in weight is small, it of prime importance for it is at this period that the fetus and placer are being formed. Failure to gain weight in the first trimester, or continue to do so in the second, increases the probability of prematu birth (*16*).

As to the amount of gain in weight, the Food and Nutrition Boa has indicated that "a gradual gain of about 22 lbs. would seem to a healthful objective for the woman who is initially at a desira

nt for her height." Many persons, of course, are not the desira-
weight for their height prior to pregnancy. Consequently the
cian may recommend that the overweight individual limit her
ic intake as a means of controlling the amount of gain, whereas
nderweight person may be accorded a more liberal allowance.
he other hand, some physicians believe that pregnancy is not the
to institute measures for correcting an overweight condition.
e size of the baby seems to be more influenced by the weight of
mother prior to pregnancy than on gain during the prenatal
d. Obese mothers tend to give birth to heavy babies even
gh the gain in weight during pregnancy may not be high. Con-
ly, underweight mothers, despite a relatively high rate of gain
ly give birth to small babies.
adequate energy intakes are found to diminish the nitrogen reten-
of women during pregnancy. In a study of 38 women Oldham
found that on the average more than twice as much nitrogen
retained by women whose protein intake was only 50 gm but
se Calorie intake was over 2100, than those whose protein intake
as much as 70 gm daily but their caloric intake was less than 2100.
lories must be limited, particular attention must be paid to sup-
ng adequate protein in the diet.
though cognizant of the individual variability in energy need,
Food and Nutrition Board recommends a 300 Calorie increase
over the prenatal level for the second half of the prenatal period.

ein

he amount of protein needed during pregnancy is greatly in-
sed, particularly in the second half of pregnancy. The major
ion of the protein acquisition by the fetus occurs in the three
ths prior to birth. The rate of protein deposition in the fetus,
puted for the entire prenatal period, is around 1.4 gm per day.
the last three months of fetal life the rate is increased to 3.6 gm
, and for the last month the increase reaches an average of 6.4
daily. Added to this are the needs of the mother, which are in-
sed to take care of the enlargement of certain of her own body
es during the prenatal period.
or the mother who is in a state of good nutrition prior to preg-
y, and the intake during the early months has been at least at
recommended level for women, the Food and Nutrition Board
mmends an additional 20 gm of protein for the last half of preg-
y. The quantitative need for protein has been studied by means
ne nitrogen balance method. From observations of a person dur-

ing the entire prenatal period, indications are that the body st
nitrogen to a greater extent than can be accounted for by the co
bined growth of the fetus and maternal tissues (7). Of course the
are additional demands for nitrogen, for at birth nitrogen is lost fro
the body in fluids and tissue in addition to the fetus, and during lac
tion the nitrogen balance is customarily negative. Furthermore, th
ready store of nitrogen is available in case of an emergency, such
illness, causing a lowered consumption of food.

It has long been concluded, even though lacking precise exper
mental work with humans, that during pregnancy proteins of goo
quality should be eaten. Progress in identification of the amino aci
essential for the human, and the development of methods for th
quantitative determination of them, has made it possible to inves
gate amino acid needs during pregnancy. The few studies that ha
been done show the excretion of threonine to be somewhat increas
over the nonpregnant state. An increase in excretion is interpreted
evidence of a greater need for that amino acid by the body (*12, 15*

Calcium

Factors influencing the calcium needs during pregnancy are co
siderably like those of protein. The amount required is influenced b
the growth both of fetal and maternal tissues, with the greatest ne
coming in the last prenatal month. At birth the fetus contains a
proximately 22 gm of calcium, most of which is deposited in the la
fetal month. The rate of accumulation of calcium in the fetus
about 50 mg per day at the third month; 120 mg daily by the seven
and by the last month it reaches 450 mg per day.

Daily dietary needs for calcium have been determined by means
balance studies. For women in a state of good nutrition prior
the prenatal period, the Recommended Allowance for the seco
half of pregnancy is 1.5 gm per day, an amount almost twice t
recommendation for a nonpregnant woman. As with protein, c
cium is stored during pregnancy beyond the estimated needs for t
new fetal and maternal tissues. This extra calcium we believe to
deposited in the bone trabeculae, where it can be drawn upon duri
lactation if the diet fails to provide enough.

In cases of undernutrition prior to the prenatal period, the intake
calcium and protein, and other nutrients as well, should be increased
the outset and continued throughout (5). Women with histories
poor nutrition prior to pregnancy, when given an adequate diet, a
found to store more calcium than women on the same diet who e
tered pregnancy in a good nutritional state.

e recommended intake for iron during the second half of the atal period is 15 mg daily. As with the other nutrients, the itative need increases with the progress of pregnancy (4). It ly by careful selection of foods that 15 mg of iron can be ved in the daily diet. Thus it becomes necessary to be on the h to include iron-rich foods. Foods that are good sources of are liver, other meats, eggs, enriched or whole-grain cereals and ls, green and leafy vegetables, and some dried fruits.

ypochromic anemia is common in pregnancy. Some believe it only a manifestation of hydremia (excess of water in the blood). n be prevented fairly well by the ingestion of an adequate diet, ugh in some instances medicinal supplementation is prescribed he physician. The organism is spared the loss of iron through struation during pregnancy which helps to compensate for the d demands.

ne

uring pregnancy the need for iodine is increased. In Switzerland re a serious lack of iodine exists in the soil, it is observed that if hers develop goiter due to an insufficient consumption of iodine, possibilities of her child having goiter also are ten times greater. regions where the incidence of goiter was highest among the hers, cretinism was more apt to occur among the children. ere 55 per cent of the people in a village were afflicted with en- ic goiter, the incidence of cretinism was around 1 per cent.

nder normal conditions the use of iodized salt can be depended n to provide an adequate amount of iodine. However, with the eased need of pregnancy, and the possibility of the intake of salt g restricted, for medical reasons, it would seem wise to consult a sician concerning additional iodine intake. Such a practice is rec- nended particularly for persons living in areas where iodine lack revalent.

vitamins

he vitamin needs during pregnancy have been less thoroughly ied than the protein and mineral requirements. It is logical to me that there is an increased demand for these nutrients during prenatal period. Research that has been done supports this point view. The recommendations of the Food and Nutrition Board the daily allowances of the vitamins are greater than the recom- dations for nonpregnant women.

Vitamins A and D. For vitamin A the Recommended Allow
for the second half of pregnancy is 6000 I.U. daily, based on
assumption that two-thirds of the total vitamin A activity of the
is derived from carotene and related compounds, and one-third fr
the preformed vitamin. The 6000 I.U. allowance daily can be s
plied easily by the combination of one quart of milk, use of butter
fortified margarine, a green vegetable, and the occasional use of liver

Deprivation of vitamin A during pregnancy in experimental anim
has been found to result in certain physical abnormalities. Newbo
rats and pigs were found to have cleft palates, defects of the skele
structure, and of the eyes. To the other extreme, excessive intake h
also caused physical abnormalities in rats. Such extremes have n
been recorded for the human.

The optimum intake of vitamin D during pregnancy is not de
nitely known. The level suggested is 400 I.U. daily for the seco
half of the prenatal period. The diet cannot be depended upon
supply this amount unless milk with added vitamin D is use
Readily available sources of the vitamin on the market include fi
liver oils and irradiated sterols of many kinds and potencies. Clinic
symptoms of vitamin D deficiency are rare in the United States a
Europe. In India, China, and other areas of the Far East, sympto
of osteomalacia (late rickets) do occur during reproduction. Amo
the women in the Far East who can appear in public only if veile
the source of vitamin D from the sun is completely eliminated.

Ascorbic acid. One hundred milligrams daily is the Recommend
Allowance for ascorbic acid during the second half of pregnanc
Two servings of citrus fruit will supply the recommended intak
Tomatoes can be depended on to provide some of the vitamin; al
cabbage, potatoes under proper conditions of preparation, bro
coli, strawberries, and canteloupe are among the good sources.

Evidence of an increased need for ascorbic acid is found in t
study of maternal blood levels. As pregnancy progresses, the a
corbic acid concentration in the maternal blood tends to decrea
However, when the intake is maintained at a high level the customa
progressive reduction does not occur.

Thiamine. Indications are that the same proportion of thiamine
energy requirement exists during pregnancy as in the normal no
pregnant state. The recommendation is 0.5 mg per 1000 Calories f
energy needs of less than 3000 Calories. If the caloric intake fa
below 2000, then the recommendation remains at 1 mg. For ea
additional 1000 Calories above the 3000 level, 0.2 mg of thiami
may be sufficient. Thiamine is supplied in good amounts by the fo
lowing foods: whole-grain and enriched cereals contain approx

cly 0.8 mg per 1000 Calories; whole milk, 0.6 mg per 1000 Calories, lean meats an average of 0.3 mg per 1000 Calories.

he association of certain common symptoms manifested during nancy with an inadequate intake of thiamine arises periodically discussion but remains controversial. Some investigators attribute symptoms of general nervous fatigue, muscle cramps, neuritis, and inia to an insufficiency of thiamine; others have failed to observe relationship.

iboflavin. The Recommended Allowance for riboflavin is 2.0 mg for the last half of pregnancy. The daily use of one quart of , together with enriched bread and cereals, and the other foods in verage mixed diet, will supply the riboflavin allowance without culty.

experimental studies with the rat, a lack of riboflavin, particu- at the thirteenth or fourteenth embryo day, may interfere with mal cartilage formation and result in malformations of the skeletal cture. Cleft palates and shortening of the mandible, tibia, fibula, us, and toes were observed (*18*).

itamin E. Although it is well established that vitamin E (alpha opherol) is essential for reproduction in animals, the need for the an is controversial. Some investigators have reported that vita- E is beneficial for women who have had histories of repeated rtions, whereas others have found it to be ineffective even though en in high dosages over long periods of time. Most agree that levels of total tocopherols in the blood rise as gestation progresses.

itamin K. Vitamin K is essential for the maintenance of the mal prothrombin level in the blood. At one time it was common ctice to administer vitamin K routinely during pregnancy and to newborn, also, for the prevention of hemorrhage in the newborn d. The practice is now being questioned on the grounds that it ncertain whether the decreased prothrombin level characteristic the newborn is a direct cause of hemorrhage. Furthermore, there ome possibility that the infant may be susceptible to an overdosage the water-soluble preparation of synthetic vitamin K with certain enerative changes in the brain (subthalamus).

The recommendation for intake of vitamin K is as follows: "In the ence of liver disease, there seems to be no reason to supplement ernal diet in this country with vitamin K" (*14*).

ds recommended in the daily diet

The following list of foods forms a basis for an adequate diet dur- pregnancy. It is wise to consult the family physician early to e individual guidance as to dietary needs.

Milk—one quart of whole milk or skim milk.
Fruits and vegetables—5 to 7 servings of fruits and vegetables, i
cluding some green and leafy and some citrus fruits or tomato
Lean meat, poultry, fish—at least one quarter of a pound of meat
fish is desirable. It is well to include a serving of liver at int
vals.
Eggs—at least one egg.
Cereals and bread—3 servings of enriched bread and cereals.
Butter and fortified margarine—should be used sparingly if weig
is being watched.
Fluids and vitamin D are needed daily.

Nutrition During Lactation

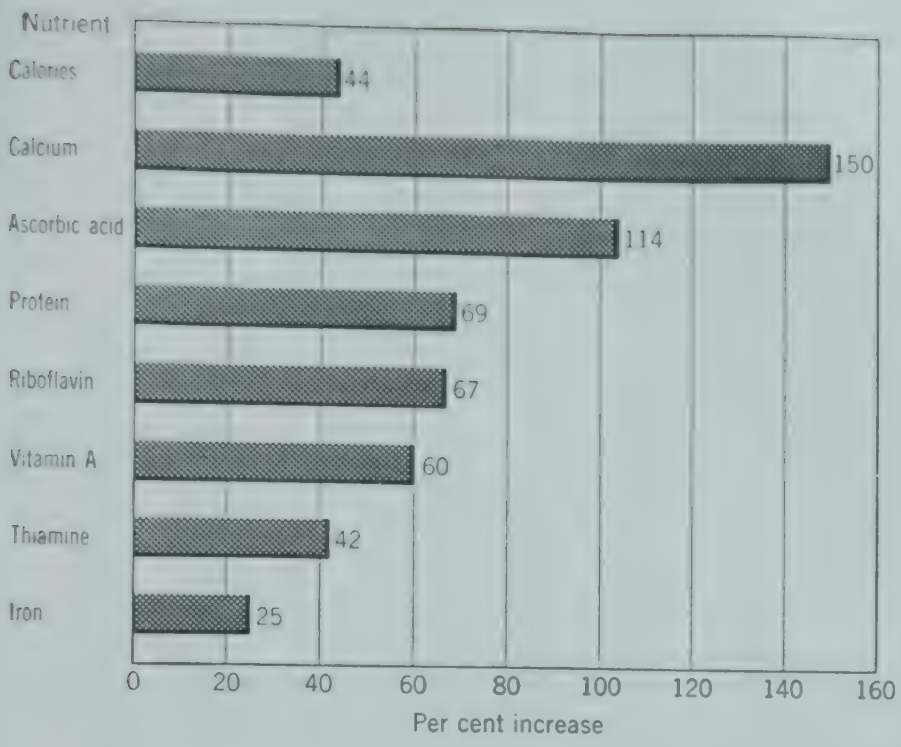
During lactation the increase in nutrient need is dependent primari
on the quantity of milk secreted. The production capacity is
individual physiologic characteristic, the realization of which is i
fluenced by the environment. Among the influences which tend
diminish the secretion of milk, and may even suppress it completel
are emotional factors, such as excitement, fear, and anxiety. Anoth
we may call demand. The breast must be completely emptied
each nursing period if the secretion of milk is to be maintained.
the infant does not require the entire content, manual expression
remove the residual portion will help to assure continued secretio

Another essential to maintenance of milk secretion is an adequa
diet. Deficiencies in the food intake eventually cause a diminution
the quantity secreted and may even alter the composition.

The Recommended Allowances proposed by the Food and Nutriti
Board were made on the basis of an average secretion of 850 ml
milk daily. The daily amounts recommended exceed those of a
other period for women. Actually the quantity of milk secret
is markedly variable among individuals. On the average the moth
who is able to nurse her infant secretes around $\frac{1}{2}$ l of milk in t
first week or two, increasing to as much as 1 l by the fifth month
lactation.

Calories

The added energy allowance for lactation recommended by t
National Research Council is 1000 Calories above that for a no
lactating woman of similar size and activity. It amounts to abo
120 Calories for 100 ml of milk secreted. The average energy val
of human milk is 70 Calories per 100 ml (*9*). If we compute t



139. Per cent increase in Recommended Allowances for women during ation (over allowances for women 25 years of age).

ergy value for 850 ml we find 600 Calories accounted for in the lk itself, leaving 400 of the 1000 Caloric allowance for other uses. There is a question as to whether the actual process of milk forma- n requires sufficient energy to be measurable. An assessment of man requirements during lactation indicates that most likely the ysiological processes of milk formation involve only a limited en- gy expenditure (*3*).

Insufficient energy in the diet will lead eventually to a diminished cretion of milk. Overfeeding, on the other hand, does not stimulate ditional milk production and seems even in some cases to diminish e quantity.

The increase in the Recommended Allowances for lactation is not ually great for energy and the nutrients. As summarized in Fig. 9, the addition to the recommended caloric intake over that for omen of 25 years is 44 per cent, whereas for calcium, ascorbic acid, otein, riboflavin, and vitamin A the increase is much greater than at. It means that the foods added to supply the additional Calories ust of necessity provide generously those nutrients needed in arkedly increased amounts; milk, citrus fruit, and eggs are ex- mples of good supplementary foods as shown in Fig. 140.

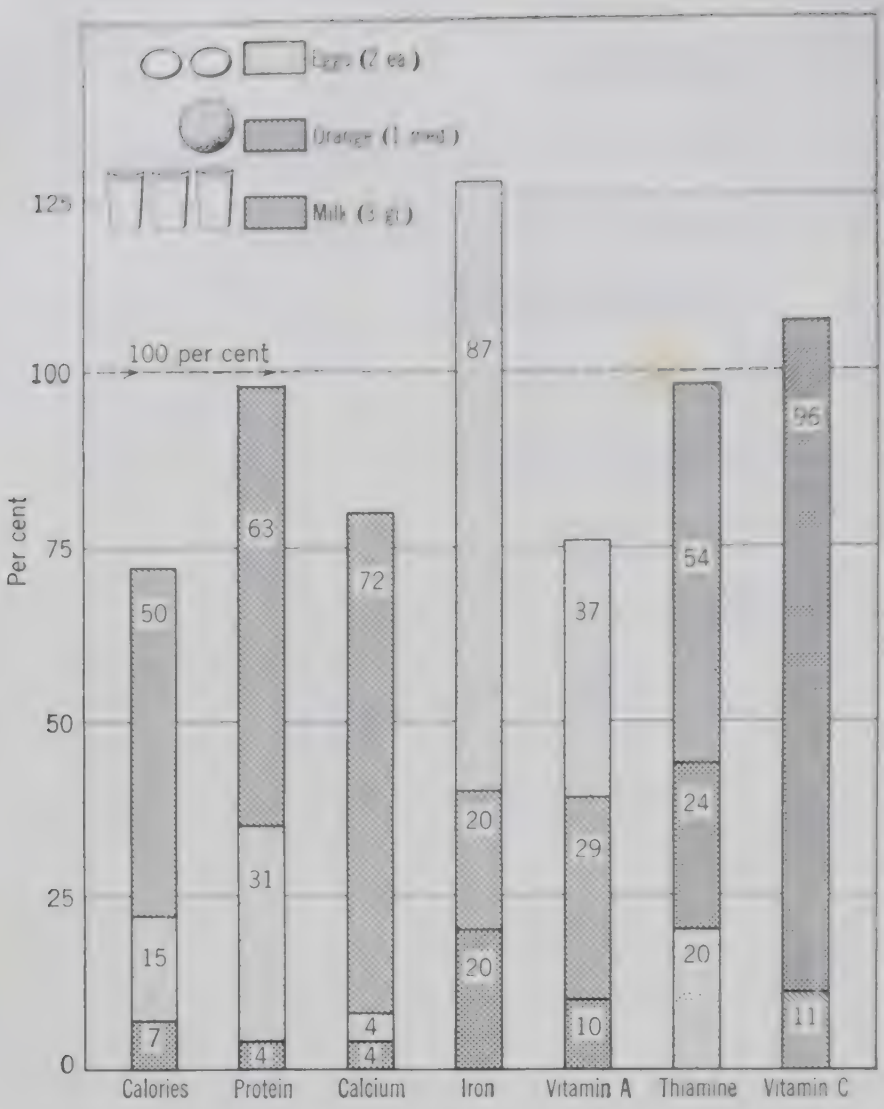


Fig. 140. Approximate per cent of the increased energy and nutrient needs fo lactation supplied by three foods.

Protein

The Recommended Allowance for protein during lactation is a 2 gm daily increase over the recommendation for pregnancy and 40 gm daily greater than for the nonpregnant woman (Table A-1, Appendix).

Inadequate protein in the diet will, as a general rule, cause a diminution in the quantity of milk secreted. There is evidence that supplying sufficient protein during both pregnancy and lactation favors milk production (7).

A question frequently asked is whether pregnancy and lactation impose a drain on the protein stores of the mother. Continuous nitrogen balance studies with one woman through most of preg-

y, and for several months after the birth of her infant revealed no to the maternal tissues in the final analysis when the storage ods and periods of loss were totaled. During the prenatal period gen was stored; at the time of birth some was lost; during lactation maternal tissues continued to lose nitrogen. Nevertheless, in this as in others observed, ample reserves deposited during pregnancy ar to be sufficient to take care of the nitrogen losses at parturition during lactation, with no drain on maternal tissue (7).

cium and phosphorus

wo grams of calcium daily, and an amount of phosphorus at least al to that of calcium is recommended during lactation. In general, alcium and protein are adequate in the diet, phosphorus is adequate .

During lactation there is a tendency for individuals to be in negative cium and phosphorus balance (*6*). It can be offset to some extent providing an adequate amount of the minerals in the diet together h a source of vitamin D (*10*).

n

Milk does contain some iron, increasing the need for that element some extent during lactation. The Food and Nutrition Board ommend that the increased allowance of 15 mg daily for pregnancy continued during lactation.

e vitamins

Less research has been done on the vitamin needs during lactation n for some of the other nutrients. The allowances proposed by National Research Council based on what research has been done, d their own wise judgment, provides for sizable increases over the ual level for some of the vitamins. The actual amount needed by mother is influenced by the quantity of milk produced.

The Recommended Allowances for the vitamins are: for vitamin 8000 I.U. daily, an increase of 60 per cent over the allowance ommended for women 25 to 45 years of age; for thiamine, 1.7 mg, increase of 42 per cent; for riboflavin 2.5 mg, an increase of 67 cent; and for ascorbic acid 150 mg, an increase of 114 per cent. r vitamin D the Food and Nutrition Board recommend 400 I.U., the ne as for pregnancy. In support of their recommendation for amin D they state:

During pregnancy and lactation the calcium and phosphorus requirements are greatly increased. Supplemental vitamin D increases the utiliza-

tion of these elements. The optimum amount of vitamin D is not known, but retention values obtained by some investigators with high dosages of vitamin D seem no greater than those with moderate dosage. On the basis of available evidence, 400 units is probably adequate (*14*).

Nutrition of Older Persons

Grow old along with me!
The best is yet to be,
The last of life, for which the first was made.

We wish with Browning for each person, pleasure in growing old. Our particular concern is that they enjoy freedom from handicaps that may have resulted from poor nutrition in their earlier years, or ill effects that may be caused by poor eating habits during their later life. As King (*8*) explicitly states, "It is not enough to survive into the years from 60 to 80, they should be years of health and enjoyment and mental vigor."

Our concern for the nutrition of the older segment of the population has continuously grown through the years, and justifiably so. The per cent of our population falling into the older age classification has been progressively on the increase. Census figures show the proportionate increase of older persons in the population of the United States. The number over 65 years old has quadrupled since 1900, whereas the population as a whole has only doubled (*13*). In 1900 there were 3 million persons over 65 years of age, in 1950, 12 million, and by 1960 it is estimated that there will be 17 to 20 million. Several factors have contributed to this change in the composition of the population. Among them are the increase in the number of births, which in turn results in more persons to grow old, and international migration. Up to the time of the First World War, immigration to the United States increased steadily each decade, except during the Civil War and the depression years of the 1890's. Another influence, the decrease in death rate, of course has increased the number of older persons in the population. The estimated average length of life is summarized in Table 47 at 10 year intervals from 1900 to 1954. Records show women to have a longer life expectancy than men, almost without exception, at each of the age levels during the time that data have been available.

Physiological changes with aging

Certain physiological changes inevitably come with aging that tend to decrease the functional capacity of the body. Changes that we

Table 47. Estimated Average Length of Life in Years

Year	All Races		
	Total	Male	Female
1954	69.6	66.8	72.9
1950	68.4	65.8	71.5
1940	62.9	60.8	65.2
1930	59.7	58.1	61.6
1920	54.1	53.6	54.6
1910	50.0	48.4	51.8
1900	47.3	46.3	48.3

om Abridged Life Tables, United States, 1954. U.S. Department of th, Education and Welfare, 1956, p. 44.

uld expect to have a direct effect on the utilization of food in- le a diminution in the size of the salivary glands, and a decrease olume and acidity of gastric juice (*3*). While there appears to ittle information on changes in the small intestine with advancing there is some evidence of a decreased rate of absorption (*2*). vements in the colon seem to be unchanged. The gross weight the liver is found to decrease between the fourth and seventh ades. A common difficulty that hinders normal eating in older sons is the loss of teeth and failure to replace them with dentures. There is evidence of less adequate carbohydrate metabolism in the er years. After consumption of a sugar solution (glucose tolerance) or following a meal that was chiefly carbohydrate, older per- s (men and women over 50 years) were found to have blood cose values that were higher than that expected for younger ilts (*6*). Stieglitz (*16*), who has been particularly concerned with processes of aging in individuals, explains that the "glucose erance test creates physiological stress" and with aging "tolerance stresses of all sorts is diminished."

anges in nutritive needs with aging

Energy. Total energy needs decrease with aging. The daily commended Allowances are as follows: for men 45 years of age ighing 70 kg, 3000 Calories; 65 years of age, 2550 Calories; for men 45 years of age weighing 58 kg, 2200 Calories; and, 65 years, 00 Calories. The estimates are for persons who are fairly active ysically. The energy need is highly individual, varying widely m person to person.

Factors that contribute to the decreasing energy need with aging

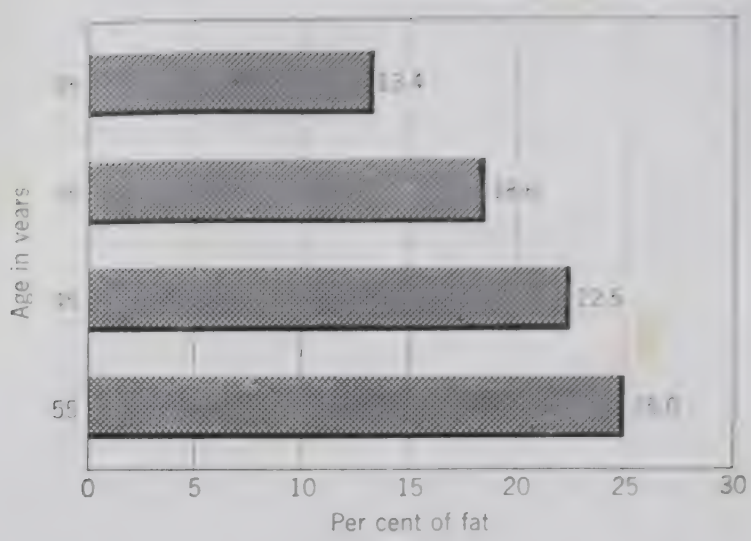


Fig. 141. Average estimated change in per cent of body weight accounted f by fat tissue. (Prepared from Brozek, *Fed. Proc.* **11**: 787, 1952.)

are a lowered basal rate, and the lessened physical activity th customarily accompanies growing older. Causes for the progressiv lowering of the basal rate, though not definitely known, are believe to be related to a combination of changes including (1) an alteratio in body composition, and (2) changes in the functioning of certai of the endocrine glands. With aging, the body tissues change i composition to relatively more fat and less muscular tissue. Est mates of the per cent of the body weight accounted for by fat in me ranging from 25 to 55 years of age are shown in Fig. 141.

In actual practice, as people grow older they tend to eat less an thus compensate to some extent for the reduced energy needs. problem that was common to persons whose diets were very low i energy value was the lowering of the nutrient content of the die Observations of 2800 women and 250 men living in parts of the Midd and Far West show, however, that the problem of too many Calori in the daily diet does exist, for many of the older persons weighe more than accepted levels considered best for their health (*1*).

A relationship between caloric intake and state of health wa found to exist in a study of the food habits of 100 women, 40 to 7 years of age (*12*). The health condition of the women was designate as *good* or *poor*, as determined by freedom from, or presence o chronic or debilitating processes, and the feeling of good or ill healt as the case might be. The mean caloric intakes for women enjoyin good health were in the upper levels, ranging from 1658 to 182 Calories per day. Those in the poor health group had intakes i

lower ranges, varying from 1122 to 1464 Calories daily. We
s that it takes special care in the selection of foods to insure an
uate supply of the essential nutrients when the quantity of food
small as that eaten by the poor health group. Whatever the
e of the poor health, an inadequate diet is certain not to aid in
ecovery.

otein. The protein needs of older persons seem not to differ
tly from those of younger healthy adults (*4, 7, 18*). The Recom-
ded Allowance is one gm per kg of body weight from young
thood to old age, 25 to 65 years.

itrogen balance studies indicate a decrease in nitrogen need after
ears of age. This is evidenced in the results of balance determina-
s, made by the North Central Regional Research group, with 136
nen 30 to 85 years of age. From the findings, amounts of protein
ded daily to assure nitrogen equilibrium for different age groups
decades was as follows: 66 gm for ages 30 to 39 years; 69 gm for
s 40 to 49; 70 gm for 50 to 59; 67 gm for 60 to 69; and 59 gm
r 70 years of age (*14*).

The essential amino acid content of the self-selected diets of 18
nen ranging in age from 33 to 77 years was determined as a part
the study in the North Central Region of the nutritional status
dietary habits of older women (*10*). The diets were analyzed
isoleucine, leucine, lysine, threonine, valine, phenylalanine, and
thionine, using microbiological methods. Methionine was least
quate in the diets, according to the present information on the
ntitative needs for amino acids, followed by phenylalanine.

Minerals and vitamins. The mineral needs of older persons have
been studied to any great extent. As with energy and protein,
investigations of mineral need have been chiefly with women thus
. Indications are that for calcium and phosphorus, the require-
nts for older women do not differ notably from those of younger
men. Calcium and phosphorus intakes sufficient in amount that
uilibrium between intake and outgo could be expected were com-
ted by Ohlson, using results from studies that she and others had
ne. The values are summarized for ages 30 to 80, by decades, in
ble 48. As with protein the need for calcium as predicted by
lson is less after 70 years than in the preceding decades beginning
30 years of age.

The amount of milk consumed by women 40 to 75 years of age was
nd in a food habits study in the Middle West, Iowa and Michigan,
be one cup or less each day. Ohlson and her co-workers who did
study called milk the "most frequently neglected food" in the

Table 48. Intakes of Calcium and Phosphorus Predicted for Equilibrium for Successive Decades in Women, 30 to 80 Years

Age range, years	No.	Intake predicted for equilibrium	
		Calcium, gm/day	Phosphorus, gm/day
30–39	25	0.88	1.25
40–49	34	0.87	1.32
50–59	40	0.83	1.42
60–69	25	0.92	1.51
70–79	11	0.73	1.13

Adapted from Ohlson et al., *Fed. Proc.* **11:** 782, 1952.

diets of these women. Two reasons seemed to account for the low consumption; there was a tendency for the women to consider milk a fattening food, and also, to consider it an expensive item in the diet (*11*).

The vitamin needs of aging individuals are not well established as yet. The National Research Council make no age differentiation in adulthood in their Recommended Allowances except for thiamine and niacin equivalent, for which the allowances are decreased in accord with the lowered energy need with increasing age.

The older person and his food

There are considerations of importance in the nutrition of aging individuals other than making available to them a nutritionally adequate food supply. The habits of eating, food likes and dislikes, and notions about food and diet are most likely of long standing and will not be readily amenable to change. Stieglitz (*17*) sounds the watchword of success in planning dietaries for older persons, when he states that, "It is essential to individualize." Consequently, the fixed habit will likely demand some respect. Under these conditions we are often called upon to recognize that there are many avenues to an adequate diet; also that to be of any good to the individual, the food must be eaten. In a practical sense it means pleasing the appetite of the aging person, and making the diet adequate within that framework.

Diet and longevity

Experimental work with animals has demonstrated that kind and amount of food and manner of feeding have an influence on length of life. Sherman (*15*), in his laboratory at Columbia University, found

when diets adequate for growth and reproduction in the white were improved, the animals responded with increased growth, a longed reproductive period, and a longer life. The nutrients added e calcium, riboflavin, and vitamin A.

nother approach to lengthening the life span through diet is that retarding the rate of growth in young animals by limiting the ric intake. McCay (9) at Cornell University, fed diets planned provide an abundance of food essentials but limited in energy value. mals on this dietary regime grew slowly, matured late, and out- d the animals who ate an adequate diet *ad libitum*.

lteration in the fat content of the diet tends to influence the span of experimental animals. Rats fed a ration containing 22.7 cent fat had a shorter life span than those fed diets that were per cent fat. The two groups of animals grew at essentially the e rate (5).

hese experimental studies on the relationship of diet to length of are fundamental to our understanding of the far-reaching influence diet on life processes. At present we do not see a direct application the human, but on the other hand, we do not summarily dismiss m as having no significance for man. Studies with the human take ger, particularly those concerned with longevity!

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Glossary

ola fruit is the tropical West Indian cherry, which is the richest known
od source of the vitamin, ascorbic acid.
dynia is a skin disorder characterized by redness and dermatitis.
e is a term used to describe symptoms that are severe.
bitum comes from the Latin, meaning at pleasure or as desired.
nalin is one of the hormones secreted by the adrenal gland.
nals are the endocrine glands located upon the kidneys.
ecia is the condition of baldness caused by disease.
o group is a characteristic group in amino acids and other compounds
mprised of nitrogen and hydrogen (NH_2).
nia is a blood disorder in which there is either an insufficient number
red cells or a suboptimal amount of hemoglobin in the cells, or both.
exia is the term used to describe the lack of appetite for food.
gonist is a chemical substance that counteracts the effects of another
emical substance.
body is any substance in the blood serum or other fluids of the body
at exerts a destructive action on bacteria.
itamin is a chemical substance that counteracts the beneficial effects
a vitamin.
hetic is indifferent or undemonstrative.
etite is the desire to eat.
oflavinosis is the term used to describe the condition resulting from a
ficiency of the vitamin, riboflavin.
riole is a minute vessel of the circulatory system carrying arterial blood.
rosclerosis is a disease in which the walls of the arteries become
rrowed due to the deposition of fats and mineral salts.
in is the protein found in uncooked egg white that has an affinity to
mbine with the vitamin, biotin, resulting in a compound that no longer
s vitamin activity.

Beriberi is a disease of the nervous system caused by a lack of or an insufficient amount of the vitamin, thiamine, in the diet.

Bicarbonate group is a chemical group (HCO_3), which contains 1 carbon, 1 hydrogen and 3 oxygen atoms. As a unit, the group carries a negative charge of electricity.

Blood volume is the total amount of blood in the body.

Bomb calorimeter is the apparatus used to measure the caloric value of a foodstuff.

Buffer is any substance which tends to prevent or lessen the change in acidic or basic concentration.

Calcification is the process whereby calcium salts are deposited in the tissues of the body.

Calorie is the standard unit in nutrition used to measure heat and, indirectly, the energy value of a foodstuff.

Capillary is a very small vessel that carries the blood from the end of the smallest artery to the beginning of the smallest vein in the body.

Carbonic anhydrase is an enzyme that contains the element zinc in its molecule; catalyzes the decomposition of carbonic acid into carbon dioxide and water and thus facilitates the exchange of carbon dioxide for oxygen in the lungs.

Carboxyl group is the acid group in organic acids ($-COOH$).

Carotenes are yellow pigments of plants.

Casein is a protein in milk.

Catalyst, in the physiological sense, is a substance essential to a reaction but does not enter into the final products formed.

Cellulose is the complex carbohydrate which makes up the skeletal parts of all plants.

Cementum is the layer of bony tissue covering the root of the tooth.

Cheilosis is the condition characterized by lesions of the lips and at the angles of the mouth, which is caused by a deficiency of the vitamin riboflavin.

Chronic is the term used to describe a condition that is of long duration.

Citrovorum factor is one of the active forms of the vitamin, folacin.

Coagulation is the process of clot formation.

Coenzyme is a substance that combines with an inactive form of an enzyme to form a new compound that has enzyme activity.

Collagen is a comparatively insoluble protein that serves as a cementing tissue between cells holding them together; it is found in bone and dentin.

Conjunctivitis is an inflammation of the tissues that cover the eyeball and line the eyelids.

Convulsion is a condition marked by involuntary contraction of the muscles.

Cornea is the transparent external covering of the front portion of the eyeball.

Costochondral relates to the cartilages at the end of the ribs.

n is a person suffering with a chronic condition characterized by ested physical and mental development caused by a lack of thyroid retion prior to and after birth.

rion is a standard for judgment.

n is the portion of a tooth which appears above the gums and is vered with enamel.

ium is a temporary mental state characterized by illusions and violent citement.

entia is a mental disorder which is characterized by mental impairment.

in is the chief substance of the tooth; it surrounds the tooth pulp and covered with enamel.

natitis is an inflammation of the skin.

umarol is the trade name for the compound dicoumarin, which delays agulation of blood.

stible means that a substance is capable of being digested.

ccharide is a carbohydrate composed of two simple sugars.

na is the presence of an abnormally large amount of fluid in the tissue aces of the body.

rocardiogram is a tracing made with an electrocardiograph, which cords the electric current produced by the contraction of the heart uscle.

ciation is the term used to describe the wasting away of body flesh.

nel is the hard substance that covers and protects teeth.

emic is a term meaning prevalent in a particular region or locality.

yme is a substance that either speeds up or slows down a biological re- tion without entering into a reaction itself.

epsy is a nervous disorder characterized by convulsive seizures and loss f consciousness.

helial tissue is the protective covering on the outside of the body and orms the mucous membranes lining the cavities of the body.

ometer is an instrument for measuring the force of muscular contraction.

hrocyte is the mature red cell of the blood that contains hemoglobin, ne carrier of oxygen to the tissues and cells.

ntial fatty acids are those fatty acids needed for good health that the ody cannot synthesize and must be obtained in food.

logy is the study or theory of the causation of any disease.

ing level is a quantitative physiological measurement taken after a num- er of hours without food, usually before breakfast.

y acid is a long chained carbon compound containing a carboxyl COOH) group that is found in every fat molecule.

s is the developing young in the human uterus.

la is the outer and the smaller of the two bones of the legs.

in is a yellow pigmented compound found in plant and animal materials.

ridation is the term used to describe the addition of fluorides to drink- g water (one part of fluoride per million parts of water) as a pro- ective agent in tooth hygiene.

Fluorosis is the chronic poisoning caused by ingesting too much fluor and is characterized by mottling of the enamel of the teeth.

Folinic acid is one of the active forms of the vitamin, folacin.

Fortified food has had added to it some nutrient such as vitamins or oth dietary essentials in an amount sufficient to make the total conte greater than the natural (unprocessed) food of its class, as in the additio of vitamin D to milk.

Gingivitis is inflammation of the gums.

Globin is the protein in hemoglobin.

Globulin is a class of proteins.

Glossitis is an inflammation of the tongue.

Glucose Tolerance Test is used to indicate the efficiency of the body to us glucose by observing the changes in the concentration of glucose in th blood after a large amount of the sugar has been ingested.

Glycerol, also called glycerin, is the alcohol found in all fats.

Goitrogenic is a term meaning goiter-producing.

Ground-substance is the semifluid or gelatinous substance between cells.

Guava is a tropical fruit that is a very rich source of the vitamin ascorbi acid.

Heme is the nonprotein, iron-containing portion of hemoglobin.

Hemeralopia is a condition of defective vision in a bright light.

Hemoglobin is the red coloring matter found in the red blood cells tha transports the oxygen from the lungs to the tissues.

Hemolysis is the process of separating hemoglobin from the red cells.

Hemopoiesis is the process whereby the constituents of the blood ar formed.

Hemorrhage is a condition in which blood escapes from the vessels. Th term is also used synonymously with bleeding.

Hemosiderin is an iron-containing pigment that is a storage form of iro

Homeostasis is a term coined by physiologist Cannon to express the tendenc of the body to maintain the normal state.

Hunger is a state in which there is a physiological need for food.

Hydremia is a condition of excess water in the blood.

Hydrolysis is the process, involving the up-take of a molecule of wate whereby a complex substance is broken down into simpler units.

Hypersecretion is excessive secretion.

Hypervitaminosis describes the condition or disorder caused by an intak of too much of a vitamin.

Hypochromic is a term meaning low pigment, a deficiency of hemoglobin i the red blood cells.

Hypoplastic means marked by defective or incomplete development.

Hypopotassemia is a disorder in which the level of the blood potassium below normal.

Hypoproteinemia is an abnormal decrease in the amount of protein in th blood.

Hyposecretion is diminished secretion.

itaminosis describes the condition or disorder caused by an intake of inadequate amount of a vitamin.

ion is the condition which results from a complete lack of food.

n is the hormone secreted by certain cells of the pancreas and is involved in the metabolism of carbohydrate in the body.

enous means into a vein.

ation is exposure to rays, such as ultraviolet or x-ray.

oric means of equal energy value.

in is a very insoluble protein found in skin, hair, and finger nails.

omalacia is a softening of the cornea of the eye.

hiorkor is a dietary deficiency disease of infants and children due marily to an inadequate intake of protein. *Kwashiorkor* is one of the ginal African tribal names, meaning *red boy*, which refers to the aracteristic (but not always present) feature of skin and hair dis- oration with the disease.

e implies something that easily decomposes or is not stable.

ratory determination involves a laboratory process which may be emical, physical, microbiological, or observations of the behavior of perimental animals.

mation is the term used to describe the discharge of tears.

albumin is one of the proteins in milk.

tude is a term used to describe a feeling of extreme weariness.

me is the class of foods including peas, beans, lentils, and soybeans.

n is an injury or loss of function of a part of the body.

argy is a condition characterized by marked sluggishness or even stupor.

ocyte is the white cell of the blood which aids in the body's defense ainst invading bacteria.

emia is a disease characterized by an overproduction of white cells nd a decrease in the number of red cells of the blood. The cause of his disease is not known.

d is an inclusive term for fat and fat-like substances.

losis is a curvature of the spinal column.

rocytic anemia is a type of anemia in which the red blood cells are nusually large.

ze is corn.

ndible is the bone forming the lower jaw.

ine plankton is a collective name for the minute organisms which live sea waters.

lian is the midpoint of a series of values with half above and half below.

rocytic anemia is a type of anemia in which the red cells are abnormally mall.

carriage is expulsion of the fetus before it is capable of independent xistence.

noiodotyrosine is an iodine-containing compound in the thyroid gland.

nosaccharide is a carbohydrate composed of one simple sugar.

Mucous membrane is modified epithelial tissue lining the canals and cavities of the body, such as the gastrointestinal and respiratory tracts.

Muscles, striated are for the most part voluntary muscles, that is, under the control of the will. Striated refers to the striped appearance of the muscle.

Neuromuscular pertains to nerves and muscles.

Nitrogen is a chemical element with the symbol "N," found free in air as combined in protein and other compounds.

Norm is a standard which has been established.

Nutrient is a substance that furnishes nourishment.

Nutriment is nutritious material.

Nyctalopia is night blindness; failure or imperfection of vision at night or in a dim light.

Occlusion refers to the contact of teeth of both jaws when closed.

Odontoblasts are the tooth cells that form the outer surface of the dental pulp adjacent to the dentin.

Oral pertains to the mouth; an oral feeding is given by mouth as opposed to some other method, as intravenous or intramuscular.

Osteoid tissue is bone tissue previous to calcification.

Osteomalacia is a softening of the bones, chiefly in adults, due to faulty calcium and phosphorus utilization.

Oxalic acid is an organic acid occurring in some foods that combines with calcium to form an insoluble salt.

Parathyroids are a group of small glands located near the thyroid in the neck, which secrete a hormone that influences the calcium content of the blood.

Parturition is the act or process of giving birth to a child.

Pellagra is a disease caused by a lack or insufficient amount of the vitamin niacin, and is characterized by dermatitis, diarrhea, and dementia.

Periodontium is the surrounding tissue in which the tooth is set.

Pernicious anemia is a type of anemia characterized by large immature red cells and caused by an inadequate supply of vitamin B_{12} to the body.

Perosis is a disorder in chicks, caused by a deficiency of either the vitamin choline, or the mineral, manganese, which results in a crippling of the legs of the bird.

Phytic acid is a phosphorus containing compound found chiefly in whole grain.

Pituitary is the small two-lobed endocrine gland at the base of the brain.

Placenta is a round, flat organ in the uterus that is the means of joining the mother and the fetus through the umbilical cord.

Polycythemia is a disorder where an above normal number of red cells are present in the blood stream.

Polyneuritis is a condition which involves the inflammation of many nerves.

Polysaccharide is a carbohydrate composed of more than two simple sugars.

rsor in nutrition means a substance that is converted into another, such rgosterol, which can be changed to vitamin D.

gestion is the partial digestion of food before it is consumed.

rmed vitamin is ready for use by the body, in contrast to a provitamin ich must first be converted to the vitamin.

tal is existing before birth.

ylactic is a tendency to ward off disease.

olysis is the process of breaking down proteins to simpler compounds, oteoses, peptones, and other products.

rombin is a substance in blood necessary for blood clot formation.

tamin is a substance that can be converted into a vitamin; the carotenes provitamins A, ergosterol is a provitamin D.

ic acid is one of the acids formed during the metabolism of the energy trients.

us is the bone on the outer or thumb side of the forearm.

dity is a condition in fats that have undergone oxidative changes, a ocess of decomposition.

onal Research Groups of the U.S. Office of the Experiment Station.

orth Central: Alaska, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, Ohio, Oklahoma, North Dakota, South Dakota, Wisconsin.

orth East: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, West Virginia.

Western: Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington.

outhern: Georgia, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas, Virginia.

net is an extract of a calf's stomach containing rennin, which is used for urdling milk in cheese making.

na is the sensitive membrane of the eye that receives the image formed the lens, and is connected with the brain by the optic nerve.

dopsin is a pigment in the retina of the eye which contains vitamin ; also known as visual purple.

ets is a disease of infancy and childhood caused by a deficiency of tamin D in which the normal processes of bone formation are disturbed.

vy is a disease caused by a deficiency of ascorbic acid, which results red and swollen gums, fleeting pains in the arms and legs, general eakness, and hemorrhages throughout the body.

orrhea is a disorder characterized by a greasy scaliness of the skin.

etal means pertaining to the bony framework of the body.

ble is an adjective that implies permanence or not changing.

ols are a group of compounds complex in structure, soluble in fat lvents; important among the sterols are the provitamins D.

birth is the birth of a dead child.

cutaneous means beneath the skin.

Synthesis is the process whereby a chemical or biological substance is b up from its individual parts.

Synthetic means artificial, in contrast to natural.

Systemic denotes pertaining to or affecting the body as a whole.

Tetany is a condition characterized by muscle twitching, cramps and c vulsions as a result of abnormal calcium metabolism.

Therapeutic is an adjective meaning curative, describing the art of h in reference to disease.

Thrombocyte is the platelet constituent of the blood that aids in blood agulation.

Thrombosis is the formation or presence of a clot (thrombus) in a blo vessel or in one of the cavities of the heart.

Thyroxine is an iodine-containing compound produced by the thyroid gl and secreted into the blood stream.

Tibia is the inner and larger bone of the leg below the knee.

Toxemia is a state of general body poisoning due to absorption of bacte products.

Toxicity is the quality of being poisonous.

Trace elements is the name that has been coined to describe a group of organic elements that are found in biological tissue in very, very sm amounts.

Transplacental means carried through the placenta.

Triiodothyronine is an iodine-containing compound produced in the thyr gland.

Trimester is a period of three months.

Ulcerated means affected with an open sore or wound.

Ultraviolet rays are rays of light of shorter wave length than the visi rays.

Uterus is the hollow muscular organ in which the fetus develops.

Visual purple is a pigment in the retina of the eye that contains vitam A; also known as rhodopsin.

Vitamin is the general name given to a group of organic substances whi are necessary in very small amounts for the normal functions of t body.

Whey is the liquid portion that separates from the curd of milk when sours.

Xerophthalmia is an abnormally dry and lusterless condition of the eyeb

Appendix

Table A-1. Food and Nutrition Board, National Research Council, Recommended Daily Dietary Allowances,* Revised 1958. Designed for the Maintenance of Good Nutrition of Healthy Persons in the U.S.A.

(Allowances are intended for persons normally active in a temperate climate)

	Age, years	Weight, kg	Weight, (lb)	Height, cm	Height, (in.)	Calories	Protein, gm	Calcium, gm	Iron, mg	Vitamin A, I.U.	Thiam., mg	Ribo., mg	Niacin,§ mg equiv.	Asc. Acid, mg	Vita. D, I.U.
Men	25	70	(154)	175	(69)	3200†	70	.8	10	5000	1.6	1.8	21	75	
	45	70	(154)	175	(69)	3000	70	.8	10	5000	1.5	1.8	20	75	
	65	70	(154)	175	(69)	2550	70	.8	10	5000	1.3	1.8	18	75	
Women	25	58	(128)	163	(64)	2300	58	.8	12	5000	1.2	1.5	17	70	
	45	58	(128)	163	(64)	2200	58	.8	12	5000	1.1	1.5	17	70	
	65	58	(128)	163	(64)	1800	58	.8	12	5000	1.0	1.5	17	70	
	Pregnant (second half)					+300	+20	1.5	15	6000	1.3	2.0	+3	100	400
	Lactating (850 ml daily)					+1000	+40	2.0	15	8000	1.7	2.5	+2	150	400
Infants‡	0–1/12‡														
	2/12–6/12	6	(13)	60	(24)	kg × 120	‡	.6	5	1500	.4	.5	6	30	400
	7/12–12/12	9	(20)	70	(28)	kg × 100		.8	7	1500	.5	.8	7	30	400
Children	1–3	12	(27)	87	(34)	1300	40	1.0	7	2000	.7	1.0	8	35	400
	4–6	18	(40)	109	(43)	1700	50	1.0	8	2500	.9	1.3	11	50	400
	7–9	27	(60)	129	(51)	2100	60	1.0	10	3500	1.1	1.5	14	60	400
	10–12	36	(79)	144	(57)	2500	70	1.2	12	4500	1.3	1.8	17	75	400
Boys	13–15	49	(108)	163	(64)	3100	85	1.4	15	5000	1.6	2.1	21	90	400
	16–19	63	(139)	175	(69)	3600	100	1.4	15	5000	1.8	2.5	25	100	400
Girls	13–15	49	(108)	160	(63)	2600	80	1.3	15	5000	1.3	2.0	17	80	400
	16–19	54	(120)	162	(64)	2400	75	1.3	15	5000	1.2	1.9	16	80	400

* The allowance levels are intended to cover individual variations among most normal persons as they live in the United States under usual environmental stresses. The recommended allowances can be attained with a variety of common foods, providing other nutrients for which human requirements have been less well defined.

† Calorie allowances apply to individuals usually engaged in moderate physical activity. For office workers or others in sedentary occupations they are excessive. Adjustments must be made for variations in body size, age, physical activity, and environmental temperature.

‡ The Board recognizes that human milk is the natural food for infants and feels that this is the best and desired procedure for meeting nutrient requirements in the first months of life. No allowances are stated for the first month of life. Breast feeding is particularly indicated during the first month when infants show handicaps in homeostasis due to different rates of maturation of digestive, excretory and endocrine functions. Recommendations as listed pertain to nutrient intake as afforded by cows' milk formulae and supplementary foods given the infant when breast feeding is terminated. Allowances are not given for protein during infancy.

§ Niacin equivalents include dietary sources of the preformed vitamin and the precursor, tryptophan.

Table A-2. Desirable Weights for Men of Ages 25 and Over

Height (with shoes, 1-in. heels)		Weight in Pounds According to Frame (as ordinarily dressed)		
Feet	Inches	Small Frame	Medium Frame	Large Frame
5	2	116–125	124–133	131–142
5	3	119–128	127–136	133–144
5	4	122–132	130–140	137–149
5	5	126–136	134–144	141–153
5	6	129–139	137–147	145–157
5	7	133–143	141–151	149–162
5	8	136–147	145–156	153–166
5	9	140–151	149–160	157–170
5	10	144–155	153–164	161–175
5	11	148–159	157–168	165–180
6	0	152–164	161–173	169–185
6	1	157–169	166–178	174–190
6	2	163–175	171–184	179–196
6	3	168–180	176–189	184–202

Table A-3. Desirable Weights for Women of Ages 25 and Over*

Height (with shoes, 2-in. heels)		Weight in Pounds According to Frame (as ordinarily dressed)		
Feet	Inches	Small Frame	Medium Frame	Large Frame
4	11	104–111	110–118	117–127
5	0	105–113	112–120	119–129
5	1	107–115	114–122	121–131
5	2	110–118	117–125	124–135
5	3	113–121	120–128	127–138
5	4	116–125	124–132	131–142
5	5	119–128	127–135	133–145
5	6	123–132	130–140	138–150
5	7	126–136	134–144	142–154
5	8	129–139	137–147	145–158
5	9	133–143	141–151	149–162
5	10	136–147	145–155	152–166
5	11	139–150	148–158	155–169

From Metropolitan Life Insurance Company.

* For girls between 18 and 25, subtract 1 lb for each year under 25.

Short Method of Dietary Analysis

he use of the short method of dietary analysis reduces the time ired to compute the nutritive value of a diet. In the evaluation of ixed dietary using this method the accuracy approximates that of putations using the conventional food table.

he values in Table A-4 were computed chiefly from the figures piled by Watt and Merrill in Agriculture Handbook 8, *Com-tion of Foods—Raw, Processed, Prepared*, supplemented by some es from the tables of Bowes and Church.

Table A-4. Food Composition Table for Short Method of Dietary Analysis (2nd revision)

Food*	Approximate Measure	Weight, gm	Calories	Protein, gm	Fat, gm	Carbohydrate, gm	Calcium, gm	Phosphorus, gm	Iron, mg	Vitamin A, I.U.	Ascorbic Acid, mg	Thiamine, mg	Riboflavin, mg	Niacin mg
Cereal products:														
Refined	1 slice bread (30 gm); ½ cup cooked cereal and cereal products (20 gm dry); ½–1 cup prep. cereal (20 gm); 3 soda crackers (20 gm); 1½ cups popcorn (20 gm); 1 griddle cake (4-in. diameter)		80	2.5	1	15	.01	.02	.2	..	.	.02	.02	.3
Whole grain and enriched	1 slice bread (30 gm); ½ cup cooked cereal (20 gm dry); ½–1 cup prepared cereal (20 gm); 2 Graham crackers (20 gm)		80	2.5	1	15	.02	.03	.6	. .	. .	.07	.04	.6
Dairy products:														
Butter	1 tsp.	5	35	...	4	...	. .	. .	.	165	. .	. .	. .	. .
Cheese, Cheddar type	1 cu in.	30	125	7.5	10	1	22	.15	.3	420	. .	.01	.13	. .
Cheese, cottage, skim	½ cup	100	95	19.5	1	2	.10	.19	.3	20	. .	.02	.31	1
Cream, light	⅛ cup (for heavy cream add ½ serving butter)	30	60	1.0	6	1	.03	.02	. .	250	. .	.01	.04	. .
Custard	½ cup	130	150	7.0	7	15	15	16	.6	440	. .	.06	.26	.1
Egg	1 medium	50	80	6.5	6	...	.03	.10	1 .4	570	. .	.05	.14	.1
Ice cream	½ cup	80	165	3.0	10	16	10	.08	.1	420	.1	.03	.15	.1
Milk														
Buttermilk, skim	1 cup	240	85	8.5	...	12	30	.23	.2	. .	.2	.10	.44	.2
Whole	1 cup	240	165	8.5	9	12	28	.22	.2	385	.2	.10	.41	.2
Desserts:														
Cake, plain, chocolate	1 piece cake 2½ × 2½ × 2½ (75 gm), for iced add 1 serving sweets; 1 waffle, 6-in. diameter (60 gm); 2½ doughnuts, cake type (add													

Fats:	2 slices bacon (20 gm raw); 1 tbsp. fat (12 gm); 1 tbsp. mayonnaise (15 gm); 1 cu. in. salt pork (15 gm); 2 tbsp. French dressing (30 gm)		105	1.5	11	...	...	.01	.2	15	...	.03	.02	.4
Fish:														
Cod, haddock, cooked	1 medium serving	75	55	13.5	..	..	01	15	4	..	1	04	.06	1.6
Halibut, herring, tuna, whitefish, cooked	1 medium serving tuna (60 gm); others (75 gm)	60	115	17.0	5	.	01	19	.8	60		04	.06	6.0
Salmon, canned	1 medium serving	75	125	15.0	7	.	11	23	.8	135		02	.12	5.6
Fruits:														
Banana	1 small	100	90	1.0	...	22	.01	.03	.6	430	10	.04	.05	.7
Cantaloupe	½ melon, 4½-in. diameter	150	30	1.0	...	7	02	02	6	5,130	50	07	06	.8
Citrus	1 medium orange; ½ medium grapefruit; ½ cup juice; 1 medium large lemon	100	45	.5	...	11	.03	.02	.4	115	45	.06	.02	.2
Yellow—fresh, canned, dried	fresh (100 gm); 1 medium peach; 2 to 3 apricots, 3 plums; dried (30 gm); for sweetened, canned, dried, or fresh, add ½ serving sweets		70	.5	...	17	.01	.03	.6	910	6	.01	.03	1.0
Other—dried	3 to 4 dates; 1½ to 2 small figs; dried apple; ¼ cup raisins	30	80	.5	...	20	.03	.03	.9	15	...	.04	.03	.3
Other—fresh and canned	½ cup	100	55	.5	...	13	.01	.01	.4	95	4	.04	.03	.2
Gravy, white sauce	¼ cup	65	105	2.5	8	6	.07	.06	.2	225	...	.04	.11	.2
Legumes:														
Beans, peas	½ cup cooked; dried (30 gm)		100	6.5	..	18	05	.13	2.0	10	1	19	07	7
Soybeans	½ cup cooked; dried (30 gm)		105	10.5	5	4	.07	.18	2.4	35		32	09	.7
Meat:														
Beef, lamb, veal, cooked	1 medium serving	75	240	19.0	18	...	.01	.15	2.3	...	...	.07	.17	3.7
Fowl, cooked	1 medium serving	75	150	15.0	10	...	.01	16	1.7	..	...	04	.08	5.2
Liver, cooked	1 small serving	60	125	14.0	5	6	.01	29	4.7	32,100	19	16	2.38	8.9

* The nutritive value of food mixtures such as macaroni and cheese, Spanish rice, chow mein, creamed vegetables, soups, and so on should be computed on the bases of the kind and approximate amount of the foods in the combination.

TABLE A-4. Food Composition Table for Short Method of Dietary Analysis (2nd revision) (*Continued*)

Food*	Approximate Measure	Weight, gm	Calories	Protein, gm	Fat, gm	Carbohydrate, gm	Calcium, gm	Phosphorus, gm	Iron, mg	Vitamin A, I.U.	Ascorbic Acid, mg	Thiamine, mg	Riboflavin mg	Niacin, mg
Luncheon meats, cooked	2 slices sausage, minced ham, dried beef, luncheon roll (30 gm); ½ frankfurter		85	6.0	7	...	.01	.05	.9	...	...	.08	.08	.8
Pork, ham, cooked	1 medium serving	75	280	18.0	23	...	.01	.16	2.2	...	...	.47	.17	3 5
Nuts	1 tbsp. peanut butter; 8 to 15 walnut halves; 16 peanuts; 12 to 15 almonds; 12 pecan halves	15	90	4.0	7	3	.01	.06	.3	...	...	.04	.02	2.3
Sweets:														
Candy, sugar, sirup	1 tbsp. sugar, jelly, jam, sirup, honey; 1 serving plain Jello, plain candy (fondant or mints, 14 gm); 6-oz bottle soft drink		55	...	...	14	...	...	...	...				
Candy bar	1 2-oz chocolate-coated bar		290	4.0	15	34	.06	.09	1.1	65	...	.04	.17	1 1
Molasses; sorghum	1 tbsp.	20	50	...	...	13	.04	.01	1.8	...			.03	
Vegetables:														
Cabbage—cooked and sauerkraut	⅔ cup	100	25	1.5	...	5	.05	.03	.5	90	30†	.05		
Cabbage, raw; cauliflower, cooked	1 cup cabbage (50 gm); ⅔ cup cauliflower (70 gm)		15	1.0	...	3	.02	.03	.5	50				
Corn; parsnips, cooked	½ cup corn; 1 large parsnip	100	85	2.0	1	19	.03	.07	.6	195	10‡	.07‡	.09‡	.6‡
Green and yellow:														
Asparagus, cooked	⅔ cup	100	20	2.0	...	3	.02	.05	1.0	1,040	18‡	13‡	.17‡	1 ‡
Broccoli, cooked	⅔ cup	100	30	3.0	...	5	.13	.08	1.3	3,400	74	.07	.15	.8
Carrots, cooked	⅔ cup	100	30	.5	...	7	.03	.03	.6	12,500	4‡	.03‡	.04‡	.4‡
Green beans, cooked	½ cup	100	25	1.5	...	5	.04	.07	.7	660	14‡	.07‡	.09‡	.6‡
Leafy green, cooked	⅔ cup spinach, turnip, kale,													

	1 small (100 gm); for fried add 1 to 2 servings fat; for French fried (50 gm) add 1 to 2 servings fat		85	2.0	...	19	.01	.06	.7	20	11‡	09‡	.03	1.0
Tomato, fresh, canned, or juice	½ cup; 1 small tomato (100 gm); for 2½ tbsp. catsup (50 gm), add ½ serving sweets		20	1.0	...	4	.01	.02	.5	1,035	18	.05	.03	.8
Other, cooked	½ cup beets, eggplant, onions, etc.	100	40	1.0	...	9	.03	.05	.6	80	8	.03	.04	.3
Other, commonly served raw	2 pieces, celery; 8 slices cucumber; ⅛ head lettuce	50	10	.5	..	2	.02	.02	.2	105	4	.02	.03	.2

* The nutritive value of food mixtures such as macaroni and cheese, Spanish rice, chow mein, creamed vegetables, soups, and so on should be computed on the basis of the kind and approximate amount of the foods in the combination.

† For sauerkraut, reduce by one-half.

‡ For canned, reduce by one-half.

¶ Calcium may be unavailable in chard, spinach, and beet greens.

Courtesy Leichsenring and Wilson, *J. Am. Dietet. Assoc.* **27**: 386, 1951.

Nutritive Values of Foods

The source of the figures in Table A-5 is *Composition of Food Raw, Processed, Prepared*, Agr. Handbook 8. Figures for w cooked and prepared foods are taken from Bowes and Church. *Fo Values of Portions Commonly Used*, 8th edition.

The abbreviation for trace (tr.) is used to indicate vitamin va that would round to zero with the number of decimal places carr in these tables. For other components that would round to zero, a z is used.

Dashes show that no basis could be found for imputing a va although there was some reason to believe that a measurable amou of the constituent might be present.

Other abbreviations used in Table A-5 are:

A. P.—as purchased	lv.—leave
av.—average	pc.—piece
c.—cup	%—per cent
diam.—diameter	sc.—scant
E. P.—edible portion	serv.—serving
hp.—heaping	sl.—slice
jc.—juice	sm.—small
lg.—large	sq.—square

Table A-5. Nutritive Value of Foods in Common Household Units

Food	Weight, gm	Approximate Measure	Calories	Protein, gm	Fat, gm	Total Carbohydrate, gm	Calcium, mg	Phosphorus, mg	Iron, mg	Vitamin A, I.U.	Thiamine mg	Riboflavin, mg	Niacin mg	Ascorbic Acid mg
Almonds, shelled	142	1 cup	848	26.4	76.8	27.8	361	674	6.2	0	.35	.95	6.5	tr.
Apple, raw, A.P.	150	1 medium	76	.4	.5	19.7	8	13	.4	120	.05	.04	.2	6
Applesauce, sweetened	254	1 cup	184	.5	.3	50.0	10	20	1.0	80	.05	.08	.1	3
Apple betty	230	1 cup	344	3.9	6.7	70.4	34	58	.2	370	.13	.09	1.1	3
Apple butter	18	1 tbsp.	33	.1	.1	8.2	3	4	.1	0	tr.	tr.	tr.	tr.
Apple juice, fresh	249	1 cup	124	.2	0	34.4	15	25	1.2	90	.05	.07	tr.	2
Apricots, raw	114	3 medium	54	1.1	.1	13.8	17	25	.5	2,990	.03	.05	.9	7
sirup pack	256	1 cup	205	1.5	.3	54.8	26	38	.8	3,460	.04	.06	.8	10
dried, sulfured	150	1 cup (40 halves, sm.)	393	7.8	.6	100.4	129	178	7.4	11,140	.02	.24	4.9	19
dried sulfured cooked sweetened	325	1 cup (approx. 25 halves)	400	4.9	.3	102.7	78	110	4.6	6,860	.01	.13	2.9	10
Asparagus, fresh, cooked	175	1 cup	36	4.2	.4	6.3	33	93	1.8	1,820	.23	.30	2.1	40
Asparagus, canned	175	1 cup, drained solids	38	4.2	.7	6.0	33	93	3.3	1,400	.11	.14	1.7	31
Avocados, raw	152	1 cup (½″ cubes)	372	2.6	40.1	7.8	15	58	.9	430	.10	.20	1.7	24
Bacon, broiled/fried	16	2 slices	97	4	8.8	.2	4	41	.5	0	.08	.05	.8	0
Bacon, Canadian, cooked	23	1 sl., 2¼″ diam. × 3/16″	57	6.6	3.1	.1	4	63	1.0	0	.16	.07	1.4	0
Banana, raw	150	1 medium	88	1.2	.2	23	8	28	.6	430	.04	.05	.7	10
Beans, red kidney	256	1 cup	230	14.6	1.0	42.0	102	317	4.9	0	.12	.12	2.0	0
Beans, baked, canned with pork & molasses	261	1 cup	325	15.1	7.8	50.1	146	295	5.5	90	.13	.09	1.2	7
Beans, baked, canned with pork & tomato sauce	261	1 cup	295	15.1	5.5	48.0	107	295	4.7	220	.13	.09	1.2	7
Beans, Lima, fresh, cooked	160	1 cup	152	8.0	.6	29.3	46	123	2.7	460	.22	.14	1.8	24
Beans, green snap, cooked, fresh	125	1 cup	27	1.8	.2	5.9	45	29	.9	830	.09	.12	.6	18
Beans, green snap, canned	125	1 cup	27	1.8	.2	5.9	45	29	2.1	630	.04	.07	.5	7
Beans, wax, canned	125	1 cup	27	1.8	.2	5.9	45	29	2.1	150	.04	.02	.5	7
Beef, cooked:														
chuck	85	1 pc. 4″ × 1½″ × 1″	265	22	19	0	9	190	2.6	0	.04	.17	4.5	0

hamburger	85	1 large	316	19	26	0	8	134	2.4	0	.03	.13	3.0	0
porterhouse	85	1 pc., 4″ × 2″ × 1″	293	20	23	0	9	145	2.6	0	.05	.15	4.0	0
rib roast (no bone)	85	1 pc., 4″ × 2″ × 1″	266	20	20	0	9	157	2.6	0	.05	.15	3.8	0
round	85	1 pc., 4″ × 2″ × 1″	197	23	11	0	9	191	2.9	0	.06	.19	4.7	0
rump	85	1 pc., 4″ × 2″ × 1″	320	18	27	0	7	72	2.1	0	.04	.13	2.6	0
sirloin	85	1 pc., 4″ × 2″ × 1″	257	20	19	0	9	149	2.5	0	.06	.16	4.1	0
Beef, dried	60	4 thin slices 4″ × 5″	115	19.4	3.6	0	11	229	2.9	0	.04	.18	2.2	0
Beef and vegetable stew	235	1 cup	252	12.9	19.3	16.7	31	176	2.6	2,520	.12	.15	3.4	15
Beer, av. 4% alcohol	240	1 cup	114	1.4	0	10.6	10	62	0	0	tr.	.06	4	0
Beets, fresh, cooked	165	1 cup diced	68	1.6	.2	16.2	35	51	1.2	30	.03	.07	5	11
Beets, canned	165	1 cup diced	68	1.6	.2	16.2	35	51	1.2	30	.02	.05	2	8
Beet greens, cooked	145	1 cup	39	2.9	.4	8.1	171*	65	4.6	10,790	.07	.23	6	22
Beverage, ginger ale	230	1 cup	80	...	...	21	...	...	...	...	...	...	...	...
Beverages, others including kola type	230	1 cup	107	...	...	28	...	...	...	...	...	...	...	...
Biscuit, enriched flour	38	1, 2½″ diam.	129	3.1	4.0	19.8	83	73	.7	0	.09	.08	.7	0
Biscuit, unenriched	38	1, 2½″ diam.	129	3.1	4.0	19.8	83	73	.2	0	.02	.03	2	0
Blackberries, raw	144	1 cup	82	1.7	1.4	18.0	46	46	1.3	280	.05	.06	5	30
Blueberries, canned, sirup	249	1 cup	245	1.0	1.0	64.7	27	15	1.2	100	.03	.03	5	33
Bluefish, baked	125	1 pc., 3¼″ × 3″ × ½″	193	34.2	5.2	0	29	366	.9	...	.15	.14	2.8	...
Bouillon cubes	4	gm 1 cube	2	.2	.1	0	...	...	...	...	...	.07	1.0	0
Brains, all kinds	85	2 pc., 2″ × 1½″ × ¾″	106	8.8	7.3	.7	14	281	3.1	0	.20	.22	3.8	15
Bran, bkft. cereal	60	1 cup, almost all bran	145	7.2	2.0	44.5	56	787	6.2	0	.22	.23	11.5	0
Bran flakes, 40%	40	1 cup	117	4.3	.8	31.5	24	249	2.0	0	.19	.09	3.5	0
Bran, raisin	50	1 cup	149	4.5	.9	39.3	30	270	2.4	0	.19	.09	3.5	0
Brazil nuts, shelled	140	1 cup	905	20.2	92.3	15.4	260	970	4.8	tr.	1.21	...	...	...
Bread, Boston, enriched	48	1 slice	105	2.3	1.0	22.1	89	76	1.4	70	.06	.08	9	0
Bread, cracked wheat, enriched	23	1 slice	60	2.0	.5	11.8	19	29	.5	0	.06	.04	6	0
Bread, French, enriched	454	1 lb	1225	36.8	12.3	236.1	109	322	8.0	0	1.1	7	10.0	0
Bread, Italian, enriched	454	1 lb	1195	39.5	3.6	243.8	59	350	8.0	0	1.1	7	10.0	0
Bread, raisin, enriched, American	23	1 slice	65	1.6	.7	13.3	18	24	.4	tr.	.06	.04	5	0
Bread, rye	23	1 slice	57	2.1	.3	12.1	17	34	.4	0	.04	.02	4	0

* Calcium may not be available because of presence of oxalic acid.

Table A-5. Nutritive Value of Foods in Common Household Units (*Continued*)

Food	Weight, gm	Approximate Measure	Calories	Protein, gm	Fat, gm	Total Carbohydrate, gm	Calcium, mg	Phosphorus, mg	Iron, mg	Vitamin A, I.U.	Thiamine, mg	Riboflavin, mg	Niacin, mg	Ascorbic Acid, mg
Bread, white, unenriched	23	1 slice	63	2.0	.7	11.9	18	21	.1	0	.01	.02	.2	0
Bread, white, enriched	23	1 slice	63	2.0	.7	11.9	18	21	.4	0	.06	.04	.5	0
Bread, whole wheat	23	1 slice	55	2.1	.6	11.3	22	60	.5	0	.07	.03	.7	0
Bread crumbs, dry	88	1 cup	339	10.5	4.0	63.8	98	114	2.3	0	.24	.19	2.7	0
Breakfast foods, ready to eat, corn & soy grits, wheat & barley	50	1 cup	177	9.0	.2	37.6	33	91	3.2	0	.34	.06	1.0	0
	105	1 cup	408	11.6	.6	86.9	49	346	3.7	0	.56	.18	4.9	0
Broccoli, fresh, cooked	150	1 cup	44	5.0	.3	8.2	195	114	2.0	5,100	.10	.22	1.2	111
Brussel sprouts, cooked	130	1 cup	60	5.7	.6	11.6	44	101	1.7	520	.05	.16	.6	61
Buckwheat flour, light	98	1 cup	342	6.3	1.2	77.9	11	86	1.0	0	.08	.04	.4	0
Butter	14	1 tbsp.	100	.1	11.3	.1	3	2	0	460	tr.	tr.	tr.	0
Butter	7	1 pat	50	0	5.7	0	1	1	0	230	tr.	tr.	tr.	0
Buttermilk, cultured, skim	244	1 cup	86	8.5	.2	12.4	288	227	.2	10	.09	.43	.3	3
Cabbage, raw, E.P.	100	1 cup	24	1.4	.2	5.3	46	31	.5	80	.06	.05	.3	50
Cabbage, cooked	170	1 cup	40	2.4	.3	9.0	78	53	.8	150	.08	.08	.5	53
Cabbage, Chinese, raw	100	1 cup	14	1.2	.3	2.4	43	41	.9	260	.03	.04	.4	31
Cakes, Angel	40	2″ sector, $\frac{1}{12}$ of 8″ diam.	108	3.4	.1	23.5	2	10	.1	0	tr.	.05	.1	0
Cake, foundation	65	1 sq., 3″ × 2″ × $1\frac{3}{4}$″	228	3.8	7.6	36.3	82	78	3	100	.02	.05	.2	0
Cake, plain, sq.	55	1 sq., 3″ × 2″ × $1\frac{1}{2}$″	180	3.5	4.5	31.4	85	75	2	70	.02	.05	.2	0
Cake, plain, iced	90	$\frac{1}{6}$ of 6″ diam.	308	4.5	8.4	54.4	91	86	.4	110	.02	.06	.2	0
Cake, plain, fudge icing	90	$\frac{1}{6}$ of 6″ diam.	314	4.0	10.4	52.6	88	91	4	110	.02	.07	.2	0
Cake, fruit, dark	30	1 pc., 2″ × 2″ × $\frac{1}{2}$″	106	1.6	4.1	16.8	29	38	.8	50	.04	.04	.3	0
Cake, cupcake, plain	40	1 ($2\frac{3}{4}$″ diam.)	131	2.6	3.3	22.8	62	55	.2	50	.01	.03	.1	0
Cake, cupcake, iced	50	1 ($2\frac{3}{4}$″ diam.)	161	2.6	3.1	31.0	58	52	.2	50	.01	.04	.1	0
Cake, pound	30	1 sl., $2\frac{3}{4}$″ × 3″ × $\frac{1}{2}$″	130	2.1	7.0	14.8	16	31	.5	100	.04	.03	.3	0
Cake, rich, iced	100	3″ sector of layer	378	4.4	14.7	58.2	88	94	.5	170	.03	.07	.2	0
Cake, sponge	40	1 pc., $\frac{1}{12}$ of 8″ diam.	117	3.2	2.0	21.8	11	44	.6	210	.02	.06	.1	0
Candy, butterscotch	28	5 pieces	116	0	2.5	24.3	6	2	.5	0	0	tr.	tr.	0
Caramels	28	4 pieces	118	.8	3.3	22.0	36	26	.7	50	.04	.04	tr.	0

Candy, fondant	28	2 pieces	101	0	0	26	0	0	0	0	0	0	0
Candy, fudge, plain	28	1 lg. piece (15 to lb)	116	.5	3.2	23.0	14	19	1	60	tr.	.02	tr.	tr.
Candy, hard	28	5 pc., 1″ × ½″	108	0	0	28	0	0	0	0	0	0	0	0
Candy, peanut brittle	28	1 pc., 2½″ × 2½″ × ½″	125	2.4	4.4	20.6	11	35	6	10	.03	.04	1.4	0
Cantaloups, raw, diced	145	1 cup	30	.9	.3	6.7	25	23	6	4,960	.07	.05	.7	47
Carrots, raw, grated	110	1 cup	45	1.3	.3	10.2	43	41	9	13,200	.06	.05	.7	7
Carrots, cooked, diced	145	1 cup	44	.9	.7	9.3	38	38	9	18,130	.07	.07	.7	6
Cashew nuts	28	12–16 nuts	164	5.2	13.7	7.7	13	121	1.4		.18	.05	.6	...
Cauliflower, raw	100	1 cup	25	2.4	.2	4.9	22	72	1.1	90	.11	.10	.6	69
Cauliflower, cooked	120	1 cup	30	2.9	.2	5.9	26	86	1.3	108	.07	.10	.6	34
Celery, raw, diced	100	1 cup	18	1.3	.2	3.7	50	40	5	0	.05	.04	.4	7
Celery, cooked, diced	130	1 cup	24	1.7	.3	4.8	65	52	6	0	.05	.04	.4	6
Cheese, blue mold	28	1 oz	104	6.1	8.6	.6	89	96	.1	350	.01	.17	.1	0
Cheese, camembert	28	1 oz	85	5.0	7.0	.5	30	52	1	290	.01	.21	.3	0
Cheese, cheddar, grated	112	1 cup	446	28.0	36.1	2.4	812	554	1.1	1,570	.03	.47	tr.	0
Cheese, cheddar, slice	28	1 thin slice	113	7.1	9.1	.6	206	140	3	400	.01	.12	tr.	0
Cheese, food, cheddar	28	1 oz (1 thin slice)	92	5.8	6.8	2.0	162	226	2	303	.01	.16	tr.	0
Cheese, cottage, skim milk	56	¼ cup	54	11	3	1.1	54	106	2	13	.01	.17	tr.	0
Cheese, cream	15	1 tbsp.	56	1.4	5.6	.3	10	15	0	220	tr.	.03	tr.	0
Cheese, limburger	28	1 oz	97	6.0	7.9	.6	167	111	2	360	.02	.14	tr.	0
Cheese, parmesan	28	1 oz	112	10.2	7.4	.8	329	233	1	300	.01	.21	.1	0
Cheese, Swiss	28	1 oz (1 thin slice)	105	7.8	7.9	.5	262	160	3	410	tr.	.11	tr.	0
Cherries, raw, pits	114	1 cup	65	1.2	.5	15.8	19	21	4	710	.05	.06	.4	9
Cherries, sour, canned, pitted	254	1 cup	122	2.0	.8	30.2	28	30	8	1,840	.07	.04	.4	14
Chicken, broiler, fried	85	¼ bird—no bone	232	22.4	13.6	3.1	18	225	1.8	240	.07	.17	9.7	0
Chicken, canned, boned	100	½ cup, scant	199	29.8	8.0	0	14	148	1.8	0	.04	.16	6.4	0
Chicken, creamed	118	½ cup, sm. serving	208	17.6	12.1	6.6	83	138	1.1	328	.04	.18	3.8	tr.
Chicken, fryer, breast, fried	96	½ breast	232	26.8	11.9	3.1	19	245	1.3	450	.07	.10	10.2	0
Chicken, roasted	80	2 sl. 3½″ × 2½″ × ¼″	158	22.6	6.9	0	16	224	1.7	0	.06	.14	7.2	0
Chile con carne (no beans)	85	⅓ cup	170	8.8	12.6	4.9	32	129	1.2	130	.01	.10	1.9	
Chili sauce	17	1 tbsp.	17	.5	1	4.0	2	3	1	320	.02	.01	.4	2
Chocolate, baking	28	1 oz	142	1.6	15.0	8.3	28*	126	1.2	20	.01	.06	3	0

* Calcium may not be available because of presence of oxalic acid.

[1] Margarine was used in cooking fryers and in cream sauce for creamed chicken.

Table A-5. Nutritive Value of Foods in Common Household Units (*Continued*)

Food	Weight, gm	Approximate Measure	Calories	Protein, gm	Fat, gm	Total Carbohydrate, gm	Calcium, mg	Phosphorus, mg	Iron, mg	Vitamin A, I.U.	Thiamine, mg	Riboflavin, mg	Niacin, mg	Ascorbic Acid, mg
Chocolate, sweetened, plain	28	1 oz	133	.6	8.4	17.8	18*	81	.8	10	.01	.04	.2	0
Chocolate bev. with milk	250	1 cup	239	8.2	12.5	26.2	260	230	.5	350	.08	.40	.3	2
Chocolate sirup	20	1 tbsp.	42	.2	.2	11.3	3*	17	.3	. . .				
Clams, canned	85	½ cup	44	6.7	.9	1.8	74	106	5.4	70	.04	.08	.9	
Cocoa, breakfast	7	1 tbsp.	21	.6	1.7	3.4	9*	50	.8	tr.	.01	.03	.2	0
Cocoa bev. with milk	250	1 cup	236	9.5	11.5	27.2	298	285	1.0	400	.10	.46	.5	3
Coconut, fresh	97	1 cup shredded	349	3.3	33.7	13.6	20	95	1.9	0	.09	.01	.2	2
Coconut, dried, sweetened	62	1 cup shredded	344	2.2	24.2	33.0	27	118	2.2	0	tr.	tr.	tr.	0
Cod, baked	95	1 pc. 4 oz before cooking	170	18.7	9.7	.7	11	220	.5	0	.05	.09	2.1	tr.
Coleslaw	120	1 cup	102	1.6	7.3	9.2	47	32	.5	80	.06	.05	.3	50
Cookies, plain & assorted	25	1 cookie, 3″ diam. × ½″ thick	109	1.5	3.2	18.8	6	16	.2	0	.01	.01	.1	0
Cookies, 2 wafers	10	2 wafers, 2⅛″ diam.	44	.6	1.3	7.5	2	6	.1	0	tr.	tr.	tr.	0
Corn, fresh, cooked	165	1 cup kernels	140	4.5	1.2	33.3	8	86	1.0	640	.18	.10	2.3	13
Corn, fresh, cooked	140	1 ear, 5″ long	84	2.7	.7	20.0	5	51	.6	390	.11	.10	1.4	8
Corn, canned	165	1 cup	140	4.5	1.2	33.3	8	86	1.0	380	.06	.10	1.5	9
Cornbread or muffin, enriched	48	1 muffin, 2¾″ diam.	106	3.2	2.3	17.6	67	74	.9	60	.08	.11	.6	0
Cornflakes	25	1 cup	96	2.0	.1	21.2	3	14	.3	0	.01	.02	.4	0
Corn grits, unenriched cooked	242	1 cup	122	2.9	.2	26.6	2	24	.2	100	.04	.01	.4	0
Corn grits, enriched, cooked	242	1 cup	122	2.9	.2	26.6	2	24	.7	100	.11	.08	1.0	0
Corn meal, dry, unenriched	145	1 cup	527	11.5	1.7	113.7	9	144	1.6	430	.20	.07	2.5	0
Corn meal, dry, enriched	145	1 cup	527	11.5	1.7	113.7	9	144	4.2	430	.64	.38	5.1	0
Cowpeas, fresh, cooked	160	1 cup	151	11.4	1.0	25.4	59	291	4.0	620	.40	.15	2.5	5.5
Crabs, canned, no bones	85	½ cup flakes	89	14.4	2.5	1.1	38	155	.8	. .	.04	.05	2.5	
Crackers, graham	14	2 medium	55	1.1	1.4	10.4	3	28	.3	0	.04	.02	.2	0
Crackers, saltines	8	2 crackers	34	.7	.9	5.7	2	7	.1	0	tr.	tr.	.1	0
Crackers, soda, plain	11	2 crackers	47	1.1	1.1	8.0	2	11	.1	0	.01	.01	.1	0

Cream, heavy or whipping	15	1 tbsp.	6	.4	0	1.4	5	10	2	6	02	02				
Cucumbers, raw	50	6 slices	283	13.1	13.4	27.8	283	295	1.2	840	11	49	3	1		
Custard, baked	248	1 cup	79	4.9	1.3	15.8	337	126	5.6	27.310	23	22	1.3	2		
Dandelion greens, cooked	180	1 cup	505	3.9	1.1	134.2	128	107	3.7	100	16	17	3.9	8		
Dates, fresh & dried	178	1 cup, pitted	136	2.1	6.7	16.9	23	92	.2	40	05	04	.4	9		
Doughnuts, cake type	32	1 average	77	6.1	5.5	.3	26	101	1.3	550	04	13	tr.	6		
Egg, hard cooked	54	1 average	106	6.8	7.9	1.4	50	120	1.3	640	05	17	tr.	9		
Egg, scrambled	62	1 average	104	3.1	.2	21.7	7	31	.2	0	01	02	.2	9		
Farina, unenriched, cooked	238	1 cup	104	3.1	.2	21.7	7	31	.5	0	10	07	.4	0		
Farina, enriched, cooked	238	1 cup	110	0	12.5	0	0	0	0	0	0	0	0	0		
Fats, cooking, vegetable	12	1 tbsp.	57	.8	.3	14.4	39	23	.6	20	03	02	.4	0		
Figs, dried	21	1 lg., 2″ × 1″	87	1.0	1.2	19.0	17	17	.3	0	04	01	.2	0		
Fig bars	25	1 large	179	1.0	.5	47.6	23	31	1.0	410	03	03	.9	5		
Fruit cocktail, canned	256	1 cup	34	8.6	0	0	0	0	0	0	0	0	0	0		
Gelatin, dry, plain	10	1 tbsp.	155	3.8	0	36.3	0	0	0	0	0	0	0	0		
Gelatin dessert, plain	239	1 cup	172	3.4	.2	42.2	14	27	.7	270	07	05	.5	7		
Gelatin dessert with fruit	241	1 cup	180	2.1	6.6	28.4	63	39	1.4	50	02	05	.6	0		
Gingerbread	55	1 pc., 2″ × 2″ × 2″	75	.9	.4	19.0	41	34	.4	20	07	04	.4	76		
Grapefruit, raw	142	½ med. 4½″ diam.	77	1.0	.4	19.6	43	35	.4	20	07	04	.4	78		
Grapefruit, raw	194	1 cup, sections	92	1.2	.2	24.1	20	32	.7	20	07	04	.4	85		
Grapefruit juice, canned	246	1 cup, unsweetened	99	1.5	.2	25.6	22	37	.7	110	11	04	.5	92		
Grapefruit-orange juice blend	246	1 cup, unsweetened	84	1.7	1.7	17.7	20	25	.7	90	07	.05	.5	.5		
Grapes, Concord, Niagara	153	1 cup	102	1.2	.6	25.9	26	33	.9	120	09	06	.4	6		
Grapes, Muscat, Thompson, Tokay	160	1 cup	170	1.0	0	46.2	25	25	.8		09	12	.2	10.		
Grapejuice, commercial	254	1 cup	41	.3	3.5	2.0	tr.	2	1	0	01	01	tr.			
Gravy, meat, brown	18	1 tbsp.	158	18.7	5.5	7.0	18	182	.6		04	09	2.6			
Haddock, fried	100	1 fillet, 4″ × 3″ × ½″	92	14.4	3.1	.6	.8	173	3.9	30	50	75	6.6	.5		
Heart, beef, lean, raw	85	⅓ heart	217	20.8	14.2	0	.	290	1.2	130	02	17	3.9			
Herring, Atlantic, broiled	85	1 medium	180	18.9	11.0	0	.56	216	1.2	0	tr.	24	2.3			
Herring, smoked, kippered	85	½ fish	62	.1	0	16.7	1	3	2	0	tr.	01	tr.			
Honey, strained	21	1 tbsp.	49	.8	0	12.8	26	24	6	60	07	04	.3	34		
Honeydew melon	150	1 wedge, 2″ × 7″														

* Calcium may not be available because of presence of oxalic acid.

Table A-5. Nutritive Value of Foods in Common Household Units (*Continued*)

Food	Weight, gm	Approximate Measure	Calories	Protein, gm	Fat, gm	Total Carbohydrate, gm	Calcium, mg	Phosphorus, mg	Iron, mg	Vitamin A, I.U.	Thiamine, mg	Riboflavin, mg	Niacin, mg	Ascorbic Acid, mg
Ice cream, plain	81	1 sl., 1/7 of qt. brick	167	3.2	10.1	16.7	100	80	.1	420	.03	.15	.1	1
Jams, marmalades, preserves	20	1 tbsp.	55	.1	.1	14.2	2	2	.1	tr.	tr.	tr.	tr.	1
Jellies	20	1 tbsp.	50	0	0	13.0	2	2	.1	tr.	tr.	tr.	tr.	1
Kale, cooked	110	1 cup	45	4.3	.7	7.9	248	68	2.4	9,220	.08	.25	1.9	56
Kidneys, beef, stewed	93	3 sl. 3¼″ × 2½″ × ¼″	169	18.0	9.7	1.1	11	265	9.5	1,242	.18	2.0	3.8	0
Kohlrabi, cooked	155	1 cup	47	3.3	.2	10.4	71	78	.9	tr.	.06	.06	.3	57
Lamb, rib chop, cooked	86	2 chops, ¾″ thick	356	20	30	0	9	170	2.6	0	.12	.22	4.8	0
Lamb, leg roast	86	2 sl. 3″ × 3¼″ × ⅛″	230	20	16	0	9	219	2.6	0	.12	.21	4.4	0
Lard	14	1 tbsp.	126	0	14	0	0	0	0	0	0	0	0	0
Lemon	100	1 medium	20	.6	.4	5.4	25	14	.4	0	.03	tr.	.1	31
Lemon juice, fresh	15	1 tbsp.	4	.1	0	1.2	2	2	0	0	.01	tr.	tr.	7
Lettuce, head	50	2 lg. or 4 sm. leaves	7	.6	.1	1.4	11	12	.2	270	.02	.04	.1	4
Lettuce, leaf	50	2 lg. or 4 sm. leaves	7	.6	.1	1.4	31	10	.6	810	.02	.04	.1	9
Lime juice, fresh	246	1 cup	58	1.0	.0	20.4	34	27	.2	0	.11	.01	.3	63
Liver, beef, fried	74	2 sl. 3″ × 2¼″ × ⅜″	172	17.5	5.8	11.2	7	311	5.8	37,315	.18	2.6	10.1	20
Liver, calf, cooked	72	2 sl. 3″ × 2¼″ × ⅜″	147	16.2	7.2	3.4	5	292	9.0	19,130	.13	2.4	11.7	15
Liver, pork, fried	74	2 sl. 3″ × 2¼″ × ⅜″	170	17.5	7.2	7.5	9	315	15.5	12,070	.25	2.3	12.2	10
Lobster, canned	100	⅔ cup meat	92	18.4	1.3	.4	65	192	.8	...	.03	.07	2.2	
Macaroni, cooked, unenriched, elbow	140	1 cup	209	7.1	.8	42.3	13	91	.8	0	.03	.02	.7	0
Macaroni, cooked, elbow, enriched	140	1 cup	209	7.1	.8	42.3	13	91	1.5	0	.24	.15	2.0	0
Macaroni & cheese baked	220	1 cup	464	17.8	24.2	43.3	420	372	1.1	990	.07	.35	.9	tr.
Mackerel, canned	100	1 pc. 4″ × 2″ × ¾″	180	21.1	10.0	0	260	288	2.2	30	.03	.33	8.8	
Mangos, raw	200	1 medium	87	9	.3	22.7	12	17	.3	8,380	.08	.07	1.2	55
Margarine, fortified	14	tbsp.	101	.1	11.3	.1	3	2	0	460	0	0	0	0
Margarine, fortified	7	1 pat	50	0	5.7	0	1	1	0	230	0	0	0	0
Milk, whole	244	1 cup	166	8.5	9.5	12.0	288	227	.2	390	.08	.43	.2	3

Milk, malted, plain, dry	9	1 tbsp.	35	1.3	.8	6.4	26	34	2				
Milk, half & half (m & cream)	242	1 cup	330	7.7	29.0	10.9	261	206	.1	1,190	.08	.38	.2	3
Molasses, light	20	1 tbsp.	50	...	...	13.0	33	9	.9	...	.01	.01	tr.	...
Molasses, medium	20	1 tbsp.	46	...	...	12.0	58	14	1.2	...	...	...	...	...
Molasses, blackstrap	20	1 tbsp.	43	...	...	11.0	116	17	2.3	...	.06	.05	.4	...
Muffins, white, enriched	48	1 med. $2\frac{3}{4}$" diam	134	3.8	4.0	20.2	99	92	.8	50	.09	.10	7	0
Mushrooms, canned	244	1 cup	28	3.4	.5	9.0	17	220	2.0	0	.04	.60	4.8	
Mustard greens, cooked	140	1 cup	31	3.2	.4	5.6	308	53	4.1	10,650	.08	.25	1.0	63
Noodles, cooked, enriched	160	1 cup	107	3.5	1.0	20.5	6	56	.8	60	.22	.10	1.7	0
Noodles, cooked, unenriched	160	1 cup	107	3.5	1.0	20.5	6	56	.6	60	.05	.03	.6	0
Oat cereal, ready-to-eat	25	1 cup	100	3.6	1.8	17.6	40	88	1.0	0	.20	.05	.5	0
Oatmeal, cooked	236	1 cup	148	5.4	2.8	26.0	21	158	1.7	0	.22	.05	.4	0
Oils, salad	14	1 tbsp.	124	0	14	0	0	0	0	0	0	0	0	0
Okra, cooked	85	8 pods, 3" long	28	1.5	.2	6.3	70	53	.6	630	.05	.05	.7	17
Olives, pickled, green	65	10 lg. olives	72	.8	7.4	2.2	48	9	.9	160	tr.	...	...	...
Olives, ripe	65	10	106	1.0	11.6	1.4	48	9	.9	40	tr.	tr.	...	...
Onions, raw	10	1 tbsp. chopped	4	.1	.0	1.0	3	4	.0	tr.	tr.	tr.	tr.	1
Onions, cooked	210	1 cup	79	2.1	.4	18.3	67	92	1.0	110	.04	.06	.4	13
Onions, young green	50	6 sm., no tops	23	.5	.1	5.3	68	12	.4	30	.02	.02	.1	12
Orange, raw	215	1 medium	70	1.4	.3	17.4	51	36	.6	290	.12	.04	.4	77
Orange, raw	193	1 cup, sections	87	1.7	.4	21.6	64	44	.8	360	.15	.05	.5	95
Orange juice, fresh	246	1 cup	108	2.0	.5	27.1	47	39	.5	460	.19	.06	.6	122
Orange juice, canned	246	1 cup, unsweetened	109	2.0	.5	27.3	25	44	.7	240	.17	.04	.6	103
Orange juice, frozen	202	6 oz. concentrate	300	5.5	1.4	74.9	69	121	2.0	670	.48	.11	1.5	285
Oyster meat, raw	240	13–19 med. (1 cup)	200	23.5	5.0	13.4	226	343	13.4	770	.35	.48	2.8	
Oyster stew	230	1 c. with 3–4 oysters	209	12.2	12.4	12.2	269	253	3.4	650	.14	.42	.9	
Pancakes, wheat, enriched	27	1 cake, 4" diam.	59	1.8	2.5	7.2	43	42	.4	50	.05	.06	.3	tr.
Pancakes, buckwheat	27	1 cake, 4" diam.	47	1.6	2.3	5.6	67	98	.3	30	.04	.04	.2	tr.
Papayas, raw	182	1 cup	71	1.1	.2	18.2	36	29	.5	3,190	.06	.07	.5	102
Parsley, raw, chopped	3.5	1 tbsp.	1	.1	0	.3	7	3	.2	290	tr.	.01	.1	7
Parsnips, cooked	155	1 cup	94	1.6	.8	21.5	88	124	1.1	0	.09	.16	.3	19
Peaches, raw	114	1 medium	46	.5	.1	12.0	8	22	.6	880	.02	.05	.9	8
Peaches, raw	168	1 cup, sliced	77	.8	.2	20.2	13	37	1.0	1,480	.04	.08	1.5	13
Peaches, canned, sirup	256	1 cup	174	1.0	3	46.6	13	36	1.0	1,160	.02	.05	1.8	11
Peaches, dried, uncooked	160	1 cup	424	4.8	1.0	111.0	70	202	11.0	5,200	.02	.31	8.6	30

Table A-5. Nutritive Value of Foods in Common Household Units (*Continued*)

Food	Weight, gm	Approximate Measure	Calories	Protein, gm	Fat, gm	Total Carbohydrate, gm	Calcium, mg	Phosphorus, mg	Iron, mg	Vitamin A, I.U.	Thiamine mg	Riboflavin, mg	Niacin mg	Ascorbic Acid, mg
Peaches, dried, cooked	305	1 cup, sweetened	366	2.4	.6	95.5	37	107	5.8	2,750	.01	.15	4.6	12
Peanuts, roasted	9	1 tbsp.	50	2.4	4.0	2.1	7	35	.2	0	.03	.01	1.5	0
Peanut butter	16	1 tbsp.	92	4.2	7.6	3.4	12	63	.3	0	.02	.02	2.6	0
Pear, raw	182	1 medium	95	1.1	.6	23.9	20	24	.5	30	.03	.06	.2	6
Pears, raw	192	1 cup, quartered	120	1.3	.8	30.3	25	31	.6	40	.04	.08	.3	8
Pears, canned, sirup	256	1 cup	174	.5	.3	47.1	20	26	.5	10	.02	.04	.4	5
Peas, green, fresh	160	1 cup, cooked	111	7.8	.6	19.4	35	195	3.0	1,150	.40	.22	3.7	24
Peas, green, canned	160	1 cup	145	7.2	1.0	27.5	51	123	3.4	1,070	.19	.10	1.6	15
Pecans, chopped	7.5	1 tbsp.	52	.7	5.5	1.0	6	24	.2	tr.	.05	.01	.1	tr.
Pepper, raw	76	1 medium	16	.8	.1	3.6	7	16	.3	400	.02	.04	.2	77
Pickles, dill	135	1 cucumber, 4" long	15	.9	.3	2.8	34	27	1.6	420	tr.	.09	1	8
Pickles, bread & butter	42	6 slices	29	.4	.1	7.1	13	11	.8	80	.01	.02	tr.	4
Pickles, sour	135	1 cucumber, 4" long	15	.7	.3	3.0	34	27	1.6	420	tr.	.09	tr.	8
Pickles, sweet	20	2 sm. 2" long	22	.2	.1	5.3	3	4	.3	20	0	tr.	tr.	1
Pickle relish	13	1 tbsp.	14	.1	.1	3.4	2	2	.2	10	0	tr.	tr.	1
Pie, apple	137	⅙ of 9" pie	331	2.8	12.8	53.3	9	32	.5	220	.04	.02	.3	1
Pie, blueberry	135	⅙ of 9" pie	291	2.8	9.3	50.6	14	30	.7	160	.02	.04	.3	5
Pie, cherry	135	⅙ of 9" pie	340	3.2	13.2	54.5	14	36	.5	520	.04	.02	.3	2
Pie, coconut	130	⅙ of 9" pie	266	6.8	11.3	34.2	162	151	1.6	290	.07	.21	.4	0
Pie, custard	130	⅙ of 9" pie	266	6.8	11.3	34.2	162	151	1.6	290	.07	.21	.4	0
Pie, lemon meringue	120	⅙ of 9" pie	302	4.3	12.1	44.9	24	61	.6	210	.04	.10	.2	1
Pie, mince	135	⅙ of 9" pie	341	3.4	9.3	61.6	22	54	3.0	10	.09	.05	.3	1
Pie, pumpkin	130	⅙ of 9" pie	263	5.5	12.5	33.5	70	105	1.0	2,480	.04	.15	.4	0
Pimientos, canned	38	1 medium	10	.3	.2	2.2	3	6	.6	870	.02	.03	.1	33
Pineapple, raw	140	1 cup, diced	74	.6	.3	19.2	22	15	.4	180	.13	.04	.5	23
Pineapple, canned, sirup	260	1 cup, crushed	204	1.0	.3	54.9	75	18	1.6	210	.20	.04	.4	24
Pineapple, canned, sirup	122	2 sm. sl. plus 2 tbsp. jc.	95	.5	.1	25.7	35	9	.7	100	.09	.02	.2	11
Pineapple, juice, canned	249	1 cup	121	.7	.2	32.4	37	20	1.2	260	.15	.04	.4	27
Plum, raw	60	1 plum, 2" diam.	29	.4	.1	7.4	10	11	.5	300	.04	.04	.3	4
Plum, canned, sirup	122	3 plums plus 2 tbsp. jc.	92	.5	.1	24.9	10	15	1.3	280	.05	.05	.7	5

		bone	338	20	28	0	9	202	2.6	0			
Pork, loin or chop	85	1 large, no bone	284	20	22	0	9	200	2.6	6	71	20	4.3	6
Pork, ham, cured	85	1 sl. 4″ × 3″ × ¼″, no bone	339	20	28	.3	9	141	2.5	0	.46	.18	3.5	0
Pork, boiled ham	58	2 thin slices	172	12.9	12.9	0	5	52	1.5	0	.57	.15	2.9	0
Pork, spiced luncheon	58	2 thin slices	164	8.4	13.8	.9	5	91	1.2	0	.18	.12	1.6	0
Potato, baked	128	1 medium	97	2.4	.1	22.3	13	65	.8	20	.11	.05	1.4	17
Potatoes, French-fried	40	8 pieces, 2″ × ½″ × ½″	157	2.2	7.6	20.8	12	61	.8	20	.07	.04	1.3	11
Potatoes, hash-browned	195	1 cup	470	6.4	22.8	62.2	35	181	2.3	60	.15	.11	3.3	14
Potatoes, mashed	195	1 c., with milk	159	4.3	1.4	33.2	53	121	1.2	80	.16	.10	1.7	14
Potatoes, mashed	195	1 cup with milk & fat	240	4.1	11.7	31.0	53	115	1.2	500	.15	.10	1.6	14
Potato chips	20	10 medium	108	1.3	7.4	9.8	6	30	.4	10	.04	.02	.6	2
Pretzels	5	5 small	18	.4	.2	3.7	1	4	0	0	tr.	tr.	tr.	0
Prunes, dried	32	4 medium	73	.6	.2	19.2	15	23	1.1	510	.03	.04	.5	1
Prunes, dried, cooked, sirup	315	1 cup (16–18 prunes)	483	2.9	.6	126.6	64	100	4.4	2,200	.09	.18	1.8	3
Prune juice	240	1 cup	170	1.0	0	46.3	60	96	4.3	...	.07	.19	1.0	2
Prune whip	135	1 cup	200	3.8	.4	50.1	35	57	2.4	1,160	.05	.15	1.0	3
Pudding, chocolate	144	½ cup	219	4.5	6.6	37.1	147	129	.2	196	.04	.22	.2	0
Pudding, lemon snow	130	1 serving, plain	114	3.1	tr.	26.5	4	5	1	0	.01	.02	tr.	10
Pudding, tapioca	105	½ cup	133	4.9	5.0	17.3	105	109	.5	313	.05	.19	.1	1
Pudding, vanilla	248	1 cup	275	8.7	9.7	38.9	290	228	.2	390	.08	.40	.2	2
Pumpkin, canned	228	1 cup	76	2.3	.7	18.0	46	82	1.6	7,750	.04	.14	1.2	...
Radishes, raw	40	4 small	4	.2	.0	8	7	6	2	10	.01	tr.	1	5
Raisins	10	1 tbsp.	26	.2	.0	7.1	8	13	3	tr.	.02	.01	tr.	tr.
Raspberries, red, raw	123	1 cup	70	1.5	.5	17.0	49	46	1.1	160	.03	.08	.4	29
Rhubarb, cooked, sirup	272	1 cup	383	1.1	.3	97.9	112*	54	1.1	70	.02	...	.2	17
Rice, converted, cooked	176	1 cup	204	4.2	.2	44.7	14	76	.5	0	.10	.02	1.9	0
Rice, white, cooked	168	1 cup	201	4.2	.2	44.0	13	76	.5	0	.02	.01	.7	0
Rice, puffed, enriched	14	1 cup	55	.8	.1	12.3	3	16	.3	0	.06	.01	.8	0
Roll, plain, unenriched	38	1 roll (12 per lb)	118	3.4	2.1	20.9	21	36	.3	0	.02	.04	.4	0
Roll, plain, enriched	38	1 roll (12 per lb)	118	3.4	2.1	20.9	21	36	.7	0	.09	.06	.8	0
Roll, sweet, enriched	55	1 roll	178	4.7	4.3	29.6	35	57	1.0	0	.13	.08	1.2	0
Rutabagas, cooked	155	1 cup	50	1.2	.2	11.6	85	64	.6	540	.08	.11	1.1	33
Rye flour, light	80	1 cup	285	7.5	.8	62.3	18	148	.9	0	.12	.06	5	0

* Calcium may not be available because of presence of oxalic acid.

Table A-5. Nutritive Value of Foods in Common Household Units (*Continued*)

Food	Weight, gm	Approximate Measure	Calories	Protein, gm	Fat, gm	Total Carbohydrate, gm	Calcium, mg	Phosphorus, mg	Iron, mg	Vitamin A, I.U.	Thiamine, mg	Riboflavin, mg	Niacin, mg	Ascorbic Acid, mg
Salad, apple, celery, walnut	154	3 hp. tbsp. 2 lg. lv. lett.	137	1.9	8.3	15.9	32	48	.8	355	.08	.07	.4	4
Salad, carrot & raisin	134	3 hp. tbsp. 2 lg. lv. lett.	153	1.9	5.8	27.9	48	65	1.5	4,708	.08	.08	.5	6
Salad, fruit, fresh with frt. dress.	195	3 hp. tbsp. 2 lg. lv. lett.	174	1.9	11.1	21.2	45	44	.8	685	.03	.09	.4	32
Salad, lettuce, tomato, may.	115	4 lvs. lettuce, 3 sl. tom.	80	1.5	5.8	6.5	20	36	.8	1,115	.05	.07	.5	19
Salad, potato	123	½ c. potato, Fr. dress.	184	1.9	10.8	21.2	21	50	.8	243	.07	.04	.8	16
Salad dressing, plain	15	1 tbsp.	58	.2	5.5	2.1	1	4	.1	20	tr.	tr.	0	0
Salad dressing, French	15	1 tbsp.	59	.1	5.3	3.0	0	0	0	0	0	0	0	0
Salad dressing, home cooked	17	1 tbsp.	23	.8	.8	2.9	14	16	.1	50	.01	.03	tr.	tr
Salad dressing, mayonnaise	13	1 tbsp.	92	.2	10.1	.4	2	8	.1	34	tr.	tr.	0	0
Salmon, cooked	120	1 steak, 4″ × 3″ × ½″	204	33.6	6.7	.2	...	500	1.4	...	.12	.33	9.8	
Salmon, red	85	½ cup	147	17.2	8.2	0	229	293	1.0	200	.03	.14	6.2	0
Sardines, Atlantic	85	1 pc. 3″ × 2½″ × 1″	182	21.9	9.4	1.0	328	498	2.3	190	.01	.15	4.1	0
Sardines, Pacific	85	1 pc. 3″ × 2½″ × 1″	171	15.1	11.5	.6	324	143	3.5	20	.01	.26	6.3	0
Sauerkraut, canned	150	1 cup	32	2.1	.4	6.6	54	27	.8	60	.05	.10	.2	24
Sausage, bologna	100	3 thin slices	221	11.8	15.9	3.6	9	112	2.2	0	.18	.19	2.7	0
Sausage, frankfurter	51	1 medium	124	7	10	1	3	25	.6	0	.08	.09	1.3	0
Sausage, liverwurst	57	2 thin slices	150	9.5	11.7	.9	5	135	3.1	3,260	.10	.63	2.6	0
Sausage, pork link	20	1 link, 3″ long	94	3.5	8.8	0	2	35	.4	0	.09	.05	.6	0
Sausage, Vienna	18	1 av. 2″ long	39	2.8	3.0	0	2	31	.4	0	.02	.02	.6	0
Scallops, fried	145	5 to 6 med. pieces	427	23.8	28.4	19.3	41	326	3.1	0	.05	.17	4.5	0
Shad, baked	88	1 serving	250	21.4	16.4	3.0	...	295	.6	...	.12	.24	8.2	
Sherbet	96	½ cup	118	1.4	0	28.8	48	38	.0	0	02	07	.0	0
Shortbread	16	2 sq. 1¾″ × 1¾″	81	1.1	3.9	10.3	2	9	.1	0	.01	tr.	.1	0
Shrimp, canned	85	½ cup	108	22.8	1.2		98	224	2.6	50	.01	.04	1.9	0
Sirup, corn	20	1 tbsp.	57	0	0	14.8	9	3	.8	0	0	tr.	tr.	0
Soup, bean	250	1 c. ready to serve	191	8.5	5.0	29.5	95	102	2.8		.10	.10	.8	
Soup, beef	250	1 c. ready to serve	100	6.0	3.5	11.0	15	62	.5	..	...	..	...	.
Soup, beef noodle	191	1 serv. 3 from can	66	2.9	2.5	7.9	10	47	1.3	..	..	.	..	
Soup, bouillon & consomme	240	1 c. ready to serve	9	2	...	0	2	24	1.0	0	0	.02		0

Soup, clam chowder	255	1 c. ready to serve	86	4 6	2 3	12 5	36	76	3 6				
Soup, cream, asparagus, celery or mushroom	255	1 c. ready to serve	201	7 1	11 7	18 4	217	176	.5	200	05	29	1 6
Soup, noodle, rice, or barley	250	1 c. ready to serve	117	6 0	4 5	13 0	82	85	2	30	02	05	7 9
Soup, pea	245	1 c. ready to serve	141	6.4	2 0	25 0	32	98	1 5	440	17	07	1 4 5
Soup, tomato	245	1 c. ready to serve	90	2 2	2 2	17 9	24	39	1 0	1 250	02	19	7 10
Soup, vegetable	250	1 c. ready to serve	82	4 2	1 8	14 5	32	59	8		05	08	1 0 8
Soup, vegetable-beef	191	1 serv. 3 from can	79	2 9	9	15 0	24	43	5				
Soybean flour, med. fat	88	1 cup	232	37 4	5 7	32 7	215	537	11 4	100	72	30	2 4 6
Spaghetti, unenriched	146	1 cup cooked	218	7.4	9	44 1	13	95	9	0	03	02	7 6
Spaghetti, enriched	146	1 cup cooked	218	7 4	.9	44 1	13	95	1 6	0	25	15	2 1 0
Spaghetti, Italian style	292	1 serv. w/ meat sauce	396	12 7	20 7	39 4	27	148	2 1	901	12	12	3 0 24
Spaghetti, Italian style	302	as above w/ grated cheese	436	15 2	23 9	39 6	99	198	2 2	1 041	12	18	3 0 24
Spaghetti, tomato sauce	220	1 av. serving	244	6 7	11 2	29 4	31	109	1 4	1 285	17	08	1 8 22
Spinach, cooked	180	1 cup	46	5.6	1 1	6 5	223*	59	3 6	21 530	14	36	1 7 54
Squash, summer cooked	210	1 cup	34	1.3	2	8 2	32	32	8	550	08	15	1 3 25
Squash, winter cooked	205	1 cup	97	3.9	.8	22 6	49	72	1 6	12 600	10	31	1 2 14
Strawberries, raw	149	1 cup	54	1.2	.7	12 4	42	40	1 2	90	04	10	4 80
Sugar, granulated	12	1 tbsp.	48	0	0	12 4				0	0	0	0 0
Sugar, powdered	8	1 tbsp.	31	0	0	8 0				0	0	0	0 0
Sugar, brown	14	1 tbsp.	51	0	0	13 1	10	5	4	0	0	0	0 0
Sugar, maple	28	1 pc. $1\frac{3}{4}'' \times 1\frac{1}{4}'' \times \frac{1}{2}''$	104			27							
Sweet potatoes, baked	120	1 med. $5'' \times 2''$	183	2.6	1.1	41 3	44	72	1 1	11,410	.12	08	9 28
Sweet potatoes, candied	175	1 sm. $3\frac{1}{2}'' \times 2\frac{1}{4}''$	314	2 6	6 3	63 4	63	79	1 6	10,940	.07	.07	9 18
Tangerine	114	1 medium	35	6	2	8 8	27	19	3	340	.06	02	2 25
Tomato, raw	150	1 medium	30	1.5	4	6 0	16	40	9	1,640	.08	06	8 35
Tomato, canned	242	1 cup	46	2 4	5	9 4	27	65	1 5	2,540	14	.08	1 7 49
Tomato juice, canned	242	1 cup	50	2 4	.5	10 4	17	36	1 0	2,540	12	07	1 8 38
Tomato catsup	17	1 tbsp.	17	3	1	4 2	2	3	1	520	.02	.01	4 2
Tomato puree, canned	249	1 cup	90	4 5	1 2	17 9	27	92	2 7	4,680	22	17	4 5 69
Tongue, beef cooked	60	3 sl. $3'' \times 2'' \times \frac{1}{8}''$	160	11 6	12 2	.2	4	100	1 5	0	.03	.13	3 5 0
Tuna, canned, drained	100	$\frac{5}{8}$ cup solids	198	29 0	8 2	0	8	351	1 4	80	.05	12	12 8 0
Turkey, roasted	80	2 sl. $3\frac{1}{2}'' \times 2\frac{5}{8}'' \times \frac{1}{4}''$	160	24 8	6 0	0	24	320	4 8	8	.06	14	5 8 0
Turnip, greens	145	1 cup	43	4 2	.6	7 8	376	72	3 5	15,370	.09	59	6 0 87

* Calcium may not be available because of presence of oxalic acid

Table A-5. Nutritive Value of Foods in Common Household Units (*Continued*)

Food	Weight, gm	Approximate Measure	Calories	Protein, gm	Fat, gm	Total Carbohydrate, gm	Calcium, mg	Phosphorus, mg	Iron, mg	Vitamin A, I.U.	Thiamine, mg	Riboflavin mg	Niacin, mg	Ascorbic Acid, mg
Turnips, cooked	155	1 cup	42	1.2	.3	9.3	62	53	.8	tr.	.06	.09	.6	28
Veal, chop, loin, fried	85	1 medium	186	21.8	9.4	0	10	219	3.0	0	.11	.27	6.7	0
Veal, cutlet, breaded	92	1 pc. 3½″ × 2¼″ × ½″	217	23.8	9.4	8.0	22	220	3.0	0	.10	.26	6.5	0
Veal, leg, roasted	80	2 sl. 2″ × 3″ × ⅛″	186	22.4	10.0	0	10	206	2.9	0	.10	.24	6.4	0
Vinegar	15	1 tbsp.	2	0	...	.8	1	2	.1					
Waffles, baked	75	1 waffle, 4½″ × 5⅝″ × ½″	216	7.0	8.0	28.4	144	153	1.4	270	.14	.20	1.0	0
Walnut, English	8	1 tbsp. chopped	49	1.1	4.8	1.2	6	28	.2	tr.	.04	.01	.1	tr.
Watermelon	100	½ cup cubes	28	.5	.2	6.9	7	12	.2	590	.05	.05	.2	6
Watermelon	600	1 sl. 6″ diam. × 1½″	168	3.0	1.2	41.4	42	72	1.2	3,540	.3	.3	1.2	36
Wheat flour, whole wheat	120	1 cup	401	13.2	1.4	81.5	26	210	1.4	0	.28	.08	2.8	0
Wheat flour, white, unenriched	110	1 cup	401	11.6	1.1	83.7	18	96	.9	0	.07	.05	1.0	0
Wheat flour, white, enriched	110	1 cup	401	11.6	1.1	83.7	18	96	3.2	0	.48	.29	3.8	0
Wheat flour, cake	100	1 cup	364	7.5	.8	79.4	17	73	.5	0	.03	.03	.7	0
Wheat, bran flakes, enriched	35	1 cup	125	3.8	.6	28.1	16	115	1.5	0	.20	.06	1.4	0
Wheat, puffed, enriched	12	1 cup	43	1.3	.2	9.6	6	39	.5	0	.07	.02	.8	0
Wheat, shredded	28	1 lg. biscuit, 4″ × 2¼″	102	2.9	.7	22.7	13	102	1.0	0	.06	.03	1.3	0
White sauce	265	1 cup	429	10.6	33.1	23.3	305	252	.3	1,350	.09	.41	.5	1

From *Composition of Foods—Raw, Processed, Prepared.* U.S. Department of Agriculture, Agriculture Handbook 8, 1950.

Food	Approximate Measure	Trypto-phan, gm	Threo-nine, gm	Isoleu-cine, gm	Leu-cine, gm	Lysine, gm	Meth-ionine, gm	Cys-tine, gm	Phenyl-alanine, gm	Valine, gm
Almonds	¾ c.	.176	.610	.873	1.454	.582	.259	.377	1.146	1.124
Beef	3″ × 3″ × 1½″	.204	.773	.916	1.434	1.529	.434	.221	.720	.972
Bread, white, 4% non-fat dry milk	4–5 slices	.091	.282	.429	.668	.225	.142	.200	.465	.435
Broccoli	⅔ c	.037	.122	.126	.163	.147	.050		.119	.170
Chicken	3 sl. 3½″ × 2½″ × ¼″	.250	.877	1.088	1.490	1.810	.537	.277	.811	1.012
Corn meal, whole, ground	⅔ c.	.056	.367	.425	1.192	.265	.171	.119	.418	.470
Egg	2 medium	.211	.637	.850	1.126	.819	.401	.299	.739	.950
Haddock	1 pc., 3″ × 3″ × ½″	.181	.789	.923	1.374	1.596	.530	.245	.676	.970
Lima beans, canned	½ c.	.049	.171	.233	.306	.240	.041	.042	.197	.246
Milk	⅜ c.	.049	.161	.223	.344	.272	.086	.031	.170	.240
Oatmeal, dry	1¼ c.	.183	.470	.733	1.065	.521	.209	.309	.758	.845
Peanut butter	6 tbsp.	.330	.803	1.228	1.816	1.066	.263	.449	1.510	1.487
Peas, canned	¾ c.	.028	.125	.156	.212	.160	.027	.037	.131	.139
Pork, loin	1 pc., 3½″ × 3″ × ¾″	.213	.761	.842	1.207	1.346	.409	.192	.646	.853
Potato, raw	1, 2½″ diam.	.021	.079	.088	.100	.107	.025	.019	.088	.107
Soybeans	⅔ c.	.526	1.504	2.054	2.946	2.414	.513	.678	1.889	2.005
Spinach	½ c.	.037	.102	.107	.176	.142	.039	.046	.099	.126

From Amino Acid Content of Foods, U.S. Department of Agriculture, 1957. Home Economics Research Report 4.

Table A-7. Food Plan at Low Cost: Suggested Weekly Quantities of Food (as Purchased, Assuming Average Choices within Groups) for 20 Sex-age Groups (1957 Revision-Tentative)

Sex-age group*	Milk and milk products,† qt	Meat, poultry, fish,‡ lb	Eggs, no.	Dry beans and peas, nuts, lb	Grain products,§ lb	Potatoes, lb	Citrus fruit, tomatoes, lb	Dark green and deep yellow vegetables, lb	Other vegetables and fruits, lb	Fats, oils, lb	Sugars, sweets, lb
Children											
Under 1 year	5.5	1.00	5	0	.75	.50	1.50	.12	1.00	.06	.12
1–3 years	5.5	1.25	5	.06	1.25	.75	1.50	.25	2.25	.12	.12
4–6 years	5.5	1.50	5	.12	.75	1.25	1.75	.25	3.25	.25	.25
7–9 years	5.5	2.00	6	.25	2.25	2.00	2.00	.50	4.25	.38	.50
Girls: 10–12 years	6.5	2.25	6	.25	2.75	2.25	2.25	.50	4.75	.38	.62
13–15 years	7.0	2.50	6	.25	3.00	2.50	2.25	.75	5.00	.50	.62
16–20 years	7.0	2.50	6	.25	2.75	2.25	2.25	.75	4.75	.38	.62
Boys: 10–12 years	6.5	2.25	6	.38	3.00	2.50	2.25	.50	5.00	.50	.75
13–15 years	7.0	2.50	6	.38	4.50	3.25	2.50	.75	5.25	.88	.75
16–20 years	7.0	3.25	6	.50	5.50	4.75	2.50	.75	5.50	1.00	1.00
Women: 21–34 years	3.5	2.50	5	.25	2.50	2.00	2.00	.75	5.00	.38	.62
35–54 years	3.5	2.50	5	.25	2.50	1.50	2.00	.75	4.50	.25	.62
55–74 years	3.5	2.50	5	.25	2.25	1.25	2.00	.75	3.50	.25	.38
75 years and over	3.5	2.50	5	.25	2.00	1.25	2.00	.75	3.00	.25	.38
Pregnant women	7.0	2.75	7	.25	2.00	1.50	2.75	1.50	2.50	.25	.38
Lactating women	10.0	3.25	7	.25	3.25	3.25	4.50	1.50	3.50	.50	.50
Men: 21–34 years	3.5	3.75	6	.38	4.25	3.25	2.25	.75	5.50	.75	1.00
35–54 years	3.5	3.50	6	.38	3.75	3.00	2.25	.75	5.00	.62	.75
55–74 years	3.5	3.25	6	.25	3.50	2.50	2.25	.75	4.75	.62	.62
75 years and over	3.5	3.25	6	.25	3.25	2.25	2.00	.75	4.50	.50	.62

From *Family Economics Review*. Institute of Home Economics, U.S. Department of Agriculture, October, 1957.

* Quantities of food suggested here are based on growth and activity levels believed to fit average conditions in this country.

† Fluid whole milk or the calcium equivalent of milk products. Count as 1 qt milk, 4⅓ lb cottage cheese (creamed), 2⅔ lb cream cheese or cheese spread, ⅓ lb other cheese, 1⅔ qt ice cream.

‡ Meat, poultry, and fish including bacon and salt pork. Protein content of group assumed to be 62 gm/lb.

§ Weight in terms of flour and cereal, count 1½ lb of bread and baked goods as 1 lb flour.

Average Choices within Groups) for 20 Sex-age Groups (1957 Revision-Tentative)

Sex-age group*	Milk and milk products,† qt	Meat, poultry, fish,‡ lb	Eggs, no.	Dry beans and peas, nuts, lb	Grain products,§ lb	Potatoes, lb	Citrus fruit, tomatoes, lb	Dark green and deep yellow vegetables, lb	Other vegetables and fruits, lb	Fats, oils, lb	Sugars, sweets, lb
Children											
Under 1 year	6.0	1.25	6	0	.75	.50	1.50	.12	1.50	.06	.12
1–3 years	6.0	1.75	6	.06	1.00	.75	1.50	.25	2.75	.12	.12
4–6 years	6.0	2.25	6	.06	1.50	1.00	2.00	.25	4.00	.31	.50
7–9 years	6.0	3.00	7	.12	2.00	1.75	2.25	.50	4.75	.50	.75
Girls: 10–12 years	6.5	4.00	7	.12	2.50	2.00	2.50	.75	5.25	.50	.75
13–15 years	7.0	4.50	7	.12	2.75	2.25	2.50	.75	5.75	.62	.75
16–20 years	7.0	4.25	7	.12	2.50	2.00	2.50	.75	5.50	.62	.75
Boys: 10–12 years	6.5	4.00	7	.25	2.75	2.25	2.50	.75	5.50	.62	.88
13–15 years	7.0	4.75	7	.25	4.25	3.00	2.75	.75	6.00	1.00	1.00
16–20 years	7.0	5.50	7	.38	5.25	4.25	3.00	.75	6.25	1.25	1.25
Women: 21–34 years	3.5	4.25	6	.12	2.25	1.50	2.50	.75	5.75	.50	.88
35–54 years	3.5	4.25	6	.12	2.00	1.25	2.50	.75	5.25	.50	.75
55–74 years	3.5	4.25	6	.12	1.75	1.25	2.25	.75	4.25	.38	.50
75 years and over	3.5	3.75	6	.12	1.75	1.00	2.25	.75	3.75	.38	.50
Pregnant women	7.0	4.75	7	.12	1.75	1.25	3.00	1.50	3.00	.25	.50
Lactating women	10.0	5.75	7	.12	3.00	2.75	4.75	1.50	4.25	.62	.75
Men: 21–34 years	3.5	5.50	7	.25	4.00	3.00	2.75	.75	6.50	1.00	1.25
35–54 years	3.5	5.25	7	.25	3.50	2.50	2.75	.75	5.75	.88	1.00
55–74 years	3.5	5.00	7	.12	3.25	2.25	2.75	.75	5.50	.75	.88
75 years and over	3.5	5.00	7	.12	2.75	2.00	2.50	.75	5.25	.62	.75

From *Family Economics Review*. Institute of Home Economics, U.S. Department of Agriculture, October, 1957.

* Quantities of food suggested here are based on growth and activity levels believed to fit average conditions in this country.

† Fluid whole milk or the calcium equivalent of milk products. Count as 1 qt milk, 4⅓ lb cottage cheese (creamed), 2⅔ lb cream cheese or cheese spread, ⅓ lb other cheese, 1⅔ qt ice cream.

‡ Meat, poultry, and fish including bacon and salt pork. Protein content of group assumed to be 62 gm/lb.

§ Weight in terms of flour and cereal; count 1½ lb of bread and baked goods as 1 lb flour.

Table A-9. Food Plan at Liberal Cost: Suggested Weekly Quantities of Food (as Purchased, Assuming Average Choices within Groups) for 20 Sex-age Groups (1957 Revision-Tentative)

Sex-age group*	Milk and milk products,† qt	Meat, poultry, fish,‡ lb	Eggs, no.	Dry beans and peas, nuts, lb	Grain products,§ lb	Potatoes, lb	Citrus fruits, tomatoes, lb	Dark green and deep yellow vegetables, lb	Other vegetables and fruits, lb	Fats, oils, lb	Sugars, sweets, lb
Children											
Under 1 year	6.0	1.25	7	0	.75	.50	1.75	.12	1.50	.12	.12
1–3 years	6.0	2.25	7	.06	1.00	.75	1.75	.25	2.75	.12	.12
4–6 years	6.0	3.00	7	.06	1.25	.75	2.25	.50	4.50	.38	.62
7–9 years	6.0	3.75	7	.12	1.75	1.50	2.75	.50	5.25	.50	.88
Girls: 10–12 years	6.5	4.75	7	.12	2.25	2.00	3.00	.75	5.50	.50	1.00
13–15 years	7.0	5.50	7	.12	2.50	2.25	3.00	.75	6.00	.62	1.00
16–20 years	7.0	5.25	7	.12	2.25	1.75	3.00	.75	5.75	.62	1.00
Boys: 10–12 years	6.5	4.75	7	.25	2.75	2.25	3.00	.75	6.00	.62	1.00
13–15 years	7.0	5.50	7	.25	4.25	3.00	3.25	.75	6.50	1.00	1.25
16–20 years	7.0	6.25	7	.38	5.25	4.25	3.50	.75	7.25	1.38	1.25
Women: 21–34 years	4.0	4.75	6	.06	2.00	1.25	3.00	.75	6.25	.50	1.12
35–54 years	4.0	4.75	6	.06	1.75	1.00	3.00	.75	6.00	.50	1.00
55–74 years	4.0	4.75	6	.06	1.50	1.00	3.00	.75	4.50	.38	.75
75 years and over	4.0	4.25	6	.06	1.50	.75	3.00	.75	4.00	.38	.62
Pregnant woman	7.0	5.25	7	.12	1.50	1.00	3.00	1.50	4.25	.38	.62
Lactating woman	10.0	6.00	7	.12	3.00	2.50	5.00	1.50	5.50	.75	1.00
Men: 21–34 years	4.0	6.00	7	.25	3.75	2.75	3.00	.75	7.13	1.00	1.50
35–54 years	4.0	5.50	7	.25	3.50	2.25	3.00	.75	6.50	.88	1.25
55–74 years	4.0	5.25	7	.12	3.25	2.00	3.00	.75	6.00	.75	1.12
75 years and over	4.0	5.25	7	.12	2.75	1.75	2.75	.75	5.75	.62	1.00

From *Family Economics Review*. Institute of Home Economics, U.S. Department of Agriculture, October, 1957.

* Quantities of food suggested here are based on growth and activity levels believed to fit average conditions in this country.

† Fluid whole milk or the calcium equivalent of milk products. Count as 1 qt milk, 4⅓ lb cottage cheese (creamed), 2¼ lb cream cheese or cheese spread, ⅓ lb other cheese, 1⅔ qt ice cream.

‡ Meat, poultry, and fish including bacon and salt pork. Protein content of group assumed to be 62 gm/lb.

§ Weight in terms of flour and cereal; count 1½ lb of bread and baked goods as 1 lb flour.

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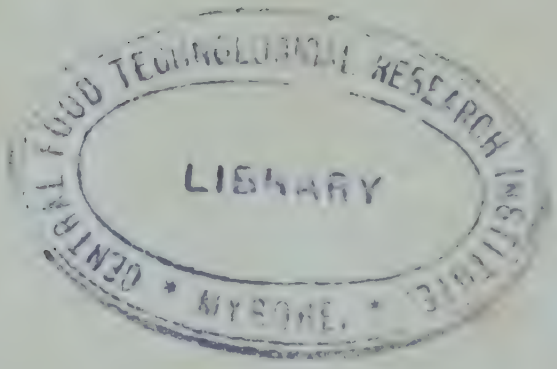
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